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AND

ATMOSPHERIC ELECTRICITY

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TABLE OF CONTENTS

MARCH, 1919

JUNE, 1919

SEPTEMBER, 1919

DECEMBER, 1919

Terrestrial Magnetism
and
Atmospheric Electricity

VOLUME XXIV — MARCH, 1919 — NUMBER 1

RESULTS OF MAGNETIC AND ELECTRIC OBSERVATIONS MADE DURING THE SOLAR ECLIPSE OF JUNE 8, 1918.—*Continued.*

BY L. A. BAUER, H. W. FISK, AND S. J. MAUCHLY.

PART I.—MAGNETIC OBSERVATIONS.—*Concluded.*

VALUES OF $\triangle X$ AND $\triangle Y$.

66. The quantities $\triangle X$ (positive towards geographic north) and $\triangle Y$ (positive towards geographic east), are derived from the $\triangle D$'s (Table 9) and $\triangle H$'s (Table 17) by means of the following formulae, $\triangle D$ being expressed in minutes of arc, H and $\triangle H$ in gammas, and D being positive for east declination:

$$\triangle X = \cos D . \triangle H - \frac{H \sin D . \triangle D}{3438} = m_1 \triangle H - m_2 \triangle D \qquad (1)$$

$$\triangle Y = \sin D . \triangle H + \frac{H \cos D . \triangle D}{3438} = m_3 \triangle H + m_4 \triangle D \qquad (2)$$

The values of the multipliers m_1, m_2, m_3, and m_4 at the stations for which there are values both of $\triangle D$ and $\triangle H$ are given in Table 20 Tables 21 and 22 contain the values of $\triangle X$ and $\triangle Y$.

TABLE 20.—*Values of multipliers for June 8, 1918.*

Station	m_1	m_2	m_3	m_4
Antipolo	1.000	+0.111	+0.010	+11.12
Lukiapang	0.998	−0.561	−0.057	+ 9.81
Kakioka	0.996	−0.803	−0.093	+ 8.61
Honolulu	0.986	+1.41	+0.168	+ 8.29
Sitka	0.862	+2.30	+0.506	+ 3.91
Goldendale	0.918	+2.31	+0.396	+ 5.37
Tucson	0.972	+1.86	+0.237	+ 7.63
Lakin	0.976	+1.43	+0.216	+ 6.45
Agincourt	0.993	−0.531	−0.115	+ 4.59
Cheltenham	0.994	−0.608	−0.109	+ 5.56
Porto Rico	0.998	−0.473	−0.058	+ 8.13

TABLE 21.—*Five-minute values of △X for June 8, 1918.*

G.M.T.	Ant.	Luk.	Kak.	Hon.	Sit.	Gol.	Tuc.	Lak.	Agi.	Che.	P. R.
h m	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
19 00	......	−0.9	+6.5	+5.8	−3.1	......	+5.4	+8.6	+14.4	+20.5	+11.7
05	......	+0.1	+6.1	+5.5	−2.9	......	+5.4	+7.8	+14.2	+20.4	+11.8
10	......	+1.1	+6.1	+5.5	−2.4	......	+5.4	+9.8	+14.1	+22.3	+11.8
15	......	+0.1	+6.6	+5.8	−1.3	−10.3	+5.8	+9.0	+17.0	+25.3	+11.8
20	......	+0.1	+6.6	+4.6	+1.1	−11.9	+5.0	+9.3	+15.0	+23.3	+11.8
25	+2.0	−0.9	+8.2	+5.5	+1.2	−6.4	+5.0	+7.2	+16.0	+23.3	+10.8
30	+2.0	−0.9	+7.6	+4.5	+2.8	−2.7	+5.0	+9.0	+16.8	+22.4	+9.8
35	+2.0	+0.1	+8.2	+4.8	+2.4	−1.4	+3.3	+5.0	+14.9	+22.3	+7.9
40	+2.0	+1.1	+8.0	+4.6	+3.3	−1.8	+0.6	+2.9	+10.9	+19.4	+7.9
45	+3.0	+1.1	+9.0	+3.5	+1.0	−5.9	−0.6	−1.0	+9.0	+18.5	+5.9
50	+4.0	+2.1	+9.0	+3.4	0.0	−5.2	−2.7	−2.1	+9.3	+16.7	+6.0
55	+5.0	+2.1	+10.0	+3.2	−0.9	−7.3	−2.7	−3.6	+9.5	+17.0	+6.1
20 00	+4.0	+2.0	+9.3	+3.1	−3.0	−7.1	−3.7	−5.1	+8.6	+16.2	+5.1
05	+4.0	+2.9	+9.2	+3.0	−4.1	−5.9	−4.7	−5.4	+7.8	+16.5	+4.2
10	+3.0	+2.9	+8.6	+3.0	−5.9	−6.9	−4.7	−7.2	+9.2	+16.7	+4.2
15	+2.0	+1.9	+8.1	+2.0	−3.4	−3.2	−4.1	−3.5	+11.3	+18.6	+4.2
20	+1.0	−0.1	+6.6	+0.8	+2.4	+3.7	−3.1	−1.5	+13.1	+18.6	+4.3
25	+2.0	−2.0	+5.7	+1.0	+8.6	+9.0	−0.8	+2.7	+11.9	+17.6	+4.3
30	+2.0	−1.9	+4.7	+1.1	+18.0	+14.7	+2.1	+7.3	+13.5	+19.4	+4.3
35	+2.0	−1.8	+3.2	+0.8	+15.8	+18.9	+4.1	+11.6	+18.5	+23.4	+4.3
40	+2.0	−0.8	+2.8	+0.7	+15.8	+18.9	+4.4	+10.1	+19.6	+23.3	+4.3
45	+1.0	−1.8	+3.3	−0.3	+13.1	+18.6	+5.6	+7.2	+16.5	+22.3	+4.2
50	+2.0	+0.1	+5.2	−1.3	+10.1	+13.6	+3.5	+4.2	+12.6	+18.4	+4.3
55	+4.0	+2.1	+7.3	−1.4	+6.0	+11.5	+5.0	+5.2	+14.7	+20.6	+6.4
21 00	+4.0	+2.1	+8.9	−4.5	−3.0	+7.1	+1.8	−1.0	+12.0	+15.8	+4.4
05	+2.0	+1.8	+9.9	−4.2	−2.3	+5.1	+1.4	−0.7	+16.4	+17.1	+4.5
10	+1.0	−0.1	+8.5	−6.2	+4.0	+9.4	+1.2	+0.1	+14.7	+15.4	+2.5
15	−1.0	−1.0	+8.0	−7.2	+7.6	+5.5	0.0	+2.1	+8.3	+11.2	+1.6
20	0.0	−2.0	+7.9	−7.2	+10.7	+9.4	0.0	+4.0	+7.2	+9.2	+1.5
25	−2.0	−3.9	+7.4	−7.2	+13.5	+9.4	+2.2	+3.9	+6.0	+8.1	+1.5
30	−1.0	−3.8	+6.7	−7.2	+14.7	+6.9	+1.2	+1.9	+4.0	+5.1	+1.5
35	−1.0	−2.8	+6.3	−7.0	+14.7	+7.1	+1.2	+2.1	+3.0	+5.2	+0.5
40	−1.1	−2.8	+7.4	−6.9	+13.5	+9.0	+2.4	+2.3	+4.8	+7.1	+1.5
45	−2.1	−3.8	+6.8	−6.8	+19.5	+15.0	+3.3	+5.4	+5.7	+6.0	+1.4
50	+0.9	−2.7	+6.9	−4.8	+19.7	+15.0	+5.4	+6.7	+6.6	+6.0	+2.4
55	+0.9	−1.6	+7.1	−2.8	+19.0	+15.4	+8.0	+13.0	+12.4	+11.8	+4.3
22 00	+1.9	−1.7	+8.1	−3.8	+15.5	+13.6	+8.0	+13.4	+13.6	+11.8	+4.3
05	+2.9	−1.9	+8.0	−4.8	+13.8	+11.3	+6.0	+11.3	+10.7	+9.8	+3.3
10	+1.9	−0.9	+7.9	−4.8	+11.2	+7.1	+4.1	+9.0	+7.7	+8.0	+3.3
15	+2.9	−1.9	+7.7	−4.8	+10.1	+7.4	+2.7	+9.9	+6.7	+6.0	+2.3
20	+2.9	−2.9	+6.2	−4.8	+10.3	+5.5	+2.2	+10.8	+6.7	+5.0	+2.3
25	+3.9	−2.8	+4.0	−4.8	+9.8	+5.8	+2.0	+9.8	+4.6	+3.9	+2.2
30	+2.9	−1.8	+2.9	−4.8	+11.6	+5.1	+1.8	+12.0	+4.6	+5.8	+3.2
35	+2.9	−1.8	+2.4	−3.8	+12.4	+7.1	+1.6	+10.9	+4.8	+6.7	+3.2
40	+1.9	−1.9	+0.8	−3.8	+14.1	+8.0	+2.6	+10.6	+3.7	+7.7	+4.1
45	+2.0	−2.9	+0.2	−3.9	+16.6	+6.7	+1.6	+9.6	+2.7	+6.8	+4.1
50	+1.0	−3.0	−0.3	−4.9	+15.5	+5.3	+0.4	+9.8	+1.7	+6.7	+4.0
55	+1.0	−4.1	−1.5	−5.9	+14.7	+2.5	−0.7	+6.7	−2.4	+3.7	+3.0
23 00	0.0	−4.2	−1.6	−6.2	+12.6	+0.7	−1.7	+6.5	−3.3	+3.7	+2.9
05	0.0	−4.2	−1.7	−6.2	+9.8	−0.9	−3.6	+6.3	−4.3	+2.8	+3.9
10	−1.0	−2.2	−1.1	−6.2	+8.0	−0.9	−3.8	+6.2	−5.2	+0.8	+2.9
15	−1.0	−2.2	−1.9	−6.1	+7.4	−1.8	−4.6	+4.1	−6.1	+0.8	+2.9
20	−1.0	−2.2	−3.1	−6.2	+7.2	−0.2	−5.0	+4.1	−5.0	+1.8	+2.9
25	−2.0	−1.2	−3.8	−6.2	+5.6	+0.2	−3.6	+8.1	−4.0	+1.8	+2.9
30	−2.0	+0.8	−3.5	−5.4	+6.3	+1.2	−2.6	+10.1	−1.9	+1.9	+3.9
35	−1.0	−0.2	−3.4	−5.2	+9.3	+2.8	−2.5	+11.2	+2.2	+5.9	+4.9
40	−2.0	−1.2	−4.6	−6.3	+9.3	+1.8	−2.5	+8.1	+2.3	+4.0	+4.9
45	−4.0	−1.2	−6.0	−6.5	+7.4	−1.4	−3.4	+1.3	−0.8	+3.0	+4.0
50	−6.0	−3.3	−7.3	−8.6	+5.0	−3.9	−5.4	−2.3	−2.8	+0.1	+3.0
55	−5.9	−4.4	−7.4	−9.6	+2.2	−4.6	−8.7	−5.0	−8.9	−3.9	+1.0
24 00	−6.9	−4.4	−6.7	−9.7	+0.9	−4.4	−7.7	−3.1	−5.5	−3.8	+1.0
05	−7.9	−4.4	−4.5	−10.8	−0.5	−3.7	−7.7	+0.5	−5.4	−1.8	0.0
10	−7.9	−5.3	−4.8	−11.1	−1.6	−3.4	−8.7	+3.4	−5.4	−1.8	0.0
15	−8.9	−4.3	−4.0	−11.6	−0.7	−5.5	−8.0	+6.8	−6.4	−3.7	+0.1
20	−8.0	−4.3	−2.6	−10.6	+0.9	−0.5	−7.1	+10.6	−4.3	−2.7	+0.1
25	−9.0	−4.3	−2.6	−10.7	+5.0	−2.3	−6.1	+12.8	−4.3	−0.6	+0.1
30	−8.0	−3.2	−2.6	−9.6	+6.5	−0.2	−5.3	+15.6	−3.3	−0.6	+0.1
35	−9.0	−3.2	−3.2	−9.6	+5.6	−1.4	−5.2	+17.4	−3.4	−0.5	+0.1
40	−8.0	−3.2	−3.8	−8.9	+4.8	+0.7	−4.2	+14.6	−2.5	+0.4	+0.1
45	−8.0	−1.2	−3.4	−8.9	+1.7	−2.0	−4.0	+12.2	−5.8	−0.6	+0.1
50	−7.0	−1.1	−3.4	−8.7	+1.7	−3.2	−2.8	+16.2	−6.0	+0.4	0.0
55	......	−0.1	−2.8	−8.7	+3.0	−6.4	−2.5	+15.6	−4.0	+2.3	0.0
25 00	....	+1.0	−1.8	−5.8	+4.6	−2.3	−2.3	+14.7	−1.0	+4.1	+1.0

TABLE 22.—*Five-minute values of $\triangle Y$ for June 8, 1918.*

G.M.T.	Ant.	Luk.	Kak.	Hon.	Sit.	Gol.	Tuc.	Lak.	Agin.	Chel.	P. R.
h m	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
19 00	......	+1.0	+1.1	−4.1	+1.3	....	+3.0	+2.7	−6.3	−14.6	−5.6
05	......	+1.0	+2.0	−2.5	+1.0	....	+3.0	+1.8	−7.7	−15.7	−4.0
10	......	+1.9	+2.0	−2.5	+0.2	....	+3.0	+2.2	−8.6	−16.5	−4.0
15	......	+2.0	+2.0	−4.1	+0.3	−8.9	+1.4	+1.2	−9.4	−17.4	−4.0
20	......	+2.0	+2.0	−3.5	+0.1	−12.8	+0.4	−0.3	−9.6	−16.6	−3.1
25	+1.1	+1.0	+1.8	−2.5	−2.0	−10.4	+0.4	0.0	−9.3	−16.6	−3.1
30	+1.1	+1.0	+1.9	−2.6	−4.7	−11.4	+0.4	+1.2	−11.2	−16.0	−3.0
35	+1.1	+2.0	+1.8	−4.3	−8.0	−12.0	−0.8	+0.3	−10.6	−16.5	−2.1
40	−1.1	+1.9	+0.1	−3.5	−9.6	−13.5	−2.3	+0.6	−10.6	−16.2	−2.1
45	−3.3	+1.9	−1.7	−2.8	−13.6	−16.6	−1.8	−0.3	−9.4	−15.0	−1.2
50	−3.3	+1.8	−1.7	−2.0	−15.8	−15.6	−1.5	+0.3	−6.7	−13.1	−0.4
55	−3.3	+0.9	−2.7	−1.2	−16.3	−15.9	−1.5	+2.4	−4.8	−10.3	+1.3
20 00	−3.3	−0.1	−3.5	−0.3	−16.5	−16.4	−1.7	+4.5	−3.8	−8.0	+2.2
05	−3.3	−2.1	−4.3	+0.5	−16.6	−14.0	−1.9	+6.0	−1.8	−5.7	+3.0
10	−3.3	−1.2	−5.1	+0.5	−15.6	−14.4	−1.9	+4.8	+1.3	−4.1	+3.0
15	−3.3	−1.1	−5.1	+0.3	−12.0	−12.8	−0.2	+6.4	+2.0	−4.3	+3.8
20	−3.3	−1.0	−4.1	+1.0	−6.0	−11.1	0.0	+6.8	+0.3	−4.3	+4.7
25	−1.1	+0.1	−2.3	+0.2	−2.8	−10.8	−1.0	+6.2	−1.4	−4.7	+4.6
30	−1.1	+2.1	−1.3	−0.7	−1.0	−11.5	−0.3	+4.0	−4.8	−6.1	+5.5
35	−1.1	+3.0	−0.3	+1.0	+0.8	−11.0	+0.2	+3.3	−5.4	−7.1	+5.4
40	+1.1	+3.0	+0.6	+1.8	+0.8	−11.0	−1.3	+0.6	−4.6	−7.6	+4.6
45	+1.1	+3.0	+0.6	+1.7	+1.4	−10.4	−1.9	0.0	−5.2	−7.5	+3.8
50	+1.1	+2.0	−1.4	+1.5	−1.4	−11.3	−1.6	−0.7	−4.2	−6.5	+4.6
55	+1.2	+1.8	−1.6	+2.3	−2.3	−11.6	+0.4	−0.5	−3.6	−4.5	+6.2
21 00	+1.2	+0.9	−2.6	+2.6	−2.8	−9.0	+1.2	−0.2	−0.5	−2.8	+6.3
05	+1.1	−3.0	−2.7	+1.0	+3.9	−6.7	+2.8	+3.1	+2.8	−0.2	+7.9
10	0.0	−1.0	−1.7	+0.6	+5.0	−4.2	+3.5	+4.0	+5.3	+2.8	+8.8
15	+1.1	+0.1	+0.1	+0.5	+0.8	−7.8	+4.1	+4.5	+2.3	+1.0	+9.7
20	+3.3	+0.1	+3.6	+0.5	+1.5	−4.2	+4.1	+4.9	+1.0	+1.2	+8.9
25	+3.3	−0.8	+5.4	+0.5	+2.7	−6.8	+3.8	+5.7	−0.2	+0.2	+8.9
30	+4.4	+3.2	+2.8	+0.5	+0.7	−8.5	+3.5	+5.2	0.0	+0.6	+8.1
35	+4.4	+4.1	+3.8	−0.4	+0.7	−9.0	+3.5	+4.3	−0.3	+1.1	+8.1
40	+5.5	+3.1	+3.8	−1.2	+2.7	−5.7	+3.0	+3.6	−1.5	+0.4	+8.1
45	+5.5	+3.2	+4.0	−2.0	+6.2	−6.9	+3.2	+3.6	−3.0	−0.1	+7.3
50	+7.8	+5.1	+5.4	−1.7	+7.9	−6.9	+3.0	+2.3	−3.6	−0.6	+6.4
55	+8.9	+7.0	+7.2	−1.3	+9.1	−8.0	+1.1	+1.2	−5.6	−2.4	+5.5
22 00	+7.8	+5.0	+6.2	−1.5	+9.1	−6.2	+1.1	−0.2	−3.9	−2.4	+5.5
05	+6.7	+2.1	+4.5	−1.7	+8.1	−6.0	+0.7	0.0	−3.1	−2.2	+5.5
10	+6.7	+2.0	+3.6	−1.7	+6.6	−6.5	+0.2	+1.1	−2.8	−0.9	+4.7
15	+7.8	+2.1	+2.8	−1.7	+6.5	−4.5	+1.5	+1.4	−3.1	−0.1	+4.8
20	+7.8	+2.1	+2.9	−1.7	+8.1	−5.2	+3.8	+2.3	−3.1	−0.5	+4.8
25	+6.7	+3.1	+2.2	−1.7	+8.9	−3.2	+4.5	+1.8	−3.3	−1.0	+3.9
30	+5.6	+3.0	+3.2	−1.7	+9.9	−4.2	+5.3	+1.5	−3.8	−1.8	+3.1
35	+5.6	+4.0	+3.2	−1.5	+10.4	−1.4	+6.0	+1.5	−2.4	−3.0	+3.1
40	+5.6	+2.1	+3.4	−1.5	+11.5	−1.0	+6.3	+3.1	−2.8	−3.1	+2.2
45	+4.5	+1.2	+2.6	−0.7	+9.2	−2.8	+6.0	+2.9	−3.1	−2.4	+2.2
50	+3.3	−0.8	+1.8	−0.8	+9.1	−2.2	+6.6	+2.1	−2.5	−3.0	+0.6
55	+2.2	−1.7	+1.0	−1.0	+6.5	−3.4	+7.1	+2.2	−3.4	−2.6	+0.6
23 00	+1.1	−2.7	+0.2	+0.6	+4.2	−4.2	+6.9	+1.9	−2.4	−2.6	−1.0
05	+1.1	−2.7	−0.7	+0.6	+3.1	−5.5	+6.4	+3.7	−2.3	−2.0	−1.0
10	+1.1	−2.8	−0.8	+0.6	+2.1	−5.5	+7.2	+4.5	−1.7	−2.3	−1.0
15	+1.1	−2.8	−3.3	−0.2	+1.2	−5.9	+6.2	+4.8	−0.7	−2.3	−1.0
20	−2.2	−2.8	−4.9	+0.6	+1.6	−4.6	+7.7	+4.8	+0.1	−2.4	−1.0
25	−2.2	−3.9	−5.7	+0.6	+2.3	−3.1	+6.4	+4.9	+0.5	−2.4	−1.0
30	−2.2	−4.0	−3.1	+1.6	+3.2	−5.2	+6.6	+5.3	+0.7	−1.3	−1.0
35	−2.2	−3.9	−2.3	+0.8	+3.9	−3.9	+5.9	+4.7	+1.6	−1.2	−1.1
40	−3.4	−2.9	−3.9	+1.5	+3.9	−4.3	+5.9	+5.0	+2.5	+0.1	−1.1
45	−3.4	−2.9	−6.4	+2.3	+3.3	−7.0	+5.6	+3.3	+1.5	+0.2	−0.2
50	−4.5	−4.7	−9.7	+2.8	+1.4	−6.1	+5.2	+1.0	+2.2	+1.1	−0.2
55	−6.7	−6.6	−10.6	+2.6	+0.2	−4.5	+6.0	−0.4	+1.5	+1.0	−0.9
24 00	−6.7	−7.6	−9.8	+3.5	+0.5	−5.1	+6.2	−0.1	+4.4	+2.1	−0.1
05	−5.6	−6.6	−7.4	+4.1	+0.8	−4.1	+6.2	+2.4	+5.3	+1.9	+0.8
10	−5.6	−5.6	−5.6	+5.8	+0.7	−2.1	+6.0	+3.0	+5.7	+2.4	+0.8
15	−5.6	−5.7	−2.2	+8.3	+1.2	−2.4	+7.7	+6.2	+5.8	+3.2	+1.6
20	−4.5	−5.7	+0.2	+8.4	+0.5	−1.5	+8.0	+7.8	+6.1	+3.1	+2.4
25	−4.5	−4.7	+0.2	+9.3	+1.4	−4.8	+8.2	+11.5	+6.1	+3.4	+2.4
30	−3.4	−3.8	+0.2	+8.6	+2.8	−4.6	+9.2	+12.9	+6.0	+4.0	+2.4
35	−3.4	−3.8	+0.3	+8.6	+2.3	−4.4	+8.4	+14.1	+5.0	+4.6	+2.4
40	−3.4	−3.8	−0.5	+10.4	+1.8	−4.2	+8.7	+12.6	+4.5	+3.9	+2.4
45	−4.5	−2.9	−2.3	+10.4	+1.0	−5.3	+7.9	+9.7	+2.5	+4.0	+1.6
50	−4.5	−1.9	−2.3	+9.6	+1.0	−7.8	+7.4	+9.9	+0.7	+3.9	+0.8
55	......	−1.0	−1.5	+9.6	+0.7	−10.4	+5.9	+8.1	0.0	+2.6	+0.8
25 00	......	−0.1	−1.6	+10.1	+0.1	−9.9	+5.1	+7.8	+0.1	+0.7	+0.8

SALIENT POINTS OF $\triangle$X-, $\triangle$Y-, AND $\triangle$Z-CURVES.

67. *$\triangle X$-curves* (*Fig. 15*).—In Table 23 are given for each station the Greenwich civil mean times of the chief salient points, *a*, *B*, *c*, *D*, etc., of the curves, as also for the entire interval of the eclipse on the Earth ($19^h\ 29^m - 24^h\ 46^m$), termed the "terrestrial eclipse-interval," and for the local eclipse interval, the average values of $\triangle X$, regardless of algebraic sign, and the maximum ranges, or differences between the highest maximum value of $\triangle X$ and the lowest minimum value. The chief crests, as indicated by the capital letters, are connected by light lines and the chief troughs are marked by small letters.

It will be noticed that lines connecting the salient points *a*, *B* and *c*, namely, those before the eclipse occurred in North America, do not depart much from vertical lines, indicating that the Greenwich mean times of the crests and troughs are in general, at all North American stations, the same within 5-15 minutes. Lines drawn through the salient points beginning with *D*, namely, through those during and after the local eclipse, tend to run parallel courses to the line supposed drawn through the points of mid-totality, as indicated on the curves by the small heavy bars.

The last columns of Table 23 show that the average five-minute value of $\triangle X$ is about the same for the terrestrial eclipse-interval and the local eclipse-interval at each station. The maximum ranges, however, are, on the average, for the terrestrial eclipse-interval about twice those for the local eclipse-interval. In fact, the maximum range for the entire eclipse-interval, $19^h\ 29^m$ to $24^h\ 46^m$, is about the same order of magnitude as for the solar-diurnal variation. (In Figs. 10, 13, 14, 15, 16, and 19, the letters at the bottom signify for the terrestrial eclipse-interval: *B*, beginning; *C. B.*, central eclipse begins; *M*, middle; *C. E.*, central eclipse ends; *E*, ending.)

TABLE 23.—*Greenwich mean times of chief salient points of $\triangle X$-curves, as also average effects, regardless of sign, and maximum ranges for June 8, 1918.*

Station	a	B	c	D	e	F	g	H	i	Terr. Ecl. Interval		Loc. Ecl. Interval	
	20^h	20^h	21^h	21^h	22^h	22^h	23^h	23^h	24^h	Av. Ef.	Range	Av. Ef.	Range
	m	m	m	m	m	m	m	m	m	γ	γ	γ	γ
Antipolo	....	....	....	—65	—98[1]	—62	....	....	....	....	....	....	....
Lukiapang	....	....	....	—52	—95	—62	....	....	....	....	....	....	....
Kakioka	....	....	....	—65	—80	—55	—85	— 60	— 5	5.5	17.4	7.2	7.2
Honolulu	....	....	....	....	—37	— 5	—42	— 22	—16[1]	5.6	17.4	5.5	4.4
Sitka	+10	+30	00	+50	+25	+45	+25	+ 38	+10	7.6	25.6	12.1	14.1
Goldendale	—05	+38	+10[1]	+55	+75	+95	+75	+100	+55	6.5	31.7	5.5	20.0
Tucson	+08	+45	+17	+58	+80	+98	+70	....	....	3.8	16.7	4.1	11.4
Lakin	+10	+35	+15	+60	+77	+95	+55	+ 95	+45	7.3	24.6	7.6	20.6
Agincourt	+05	+40	+35	+60	+75	+100	+55	+100	+50	8.1	28.5	4.1	13.7
Cheltenham	00	+35	+30	+58	+73	+95	+55	+100	+45	10.1	29.2	3.4	11.6
Porto Rico	+30	+55	+35	+58	+77	+98	+90	....	....	....	....	....	....
Means										6.8	23 9	6.2	12.9

[1]Mean of two or more points.

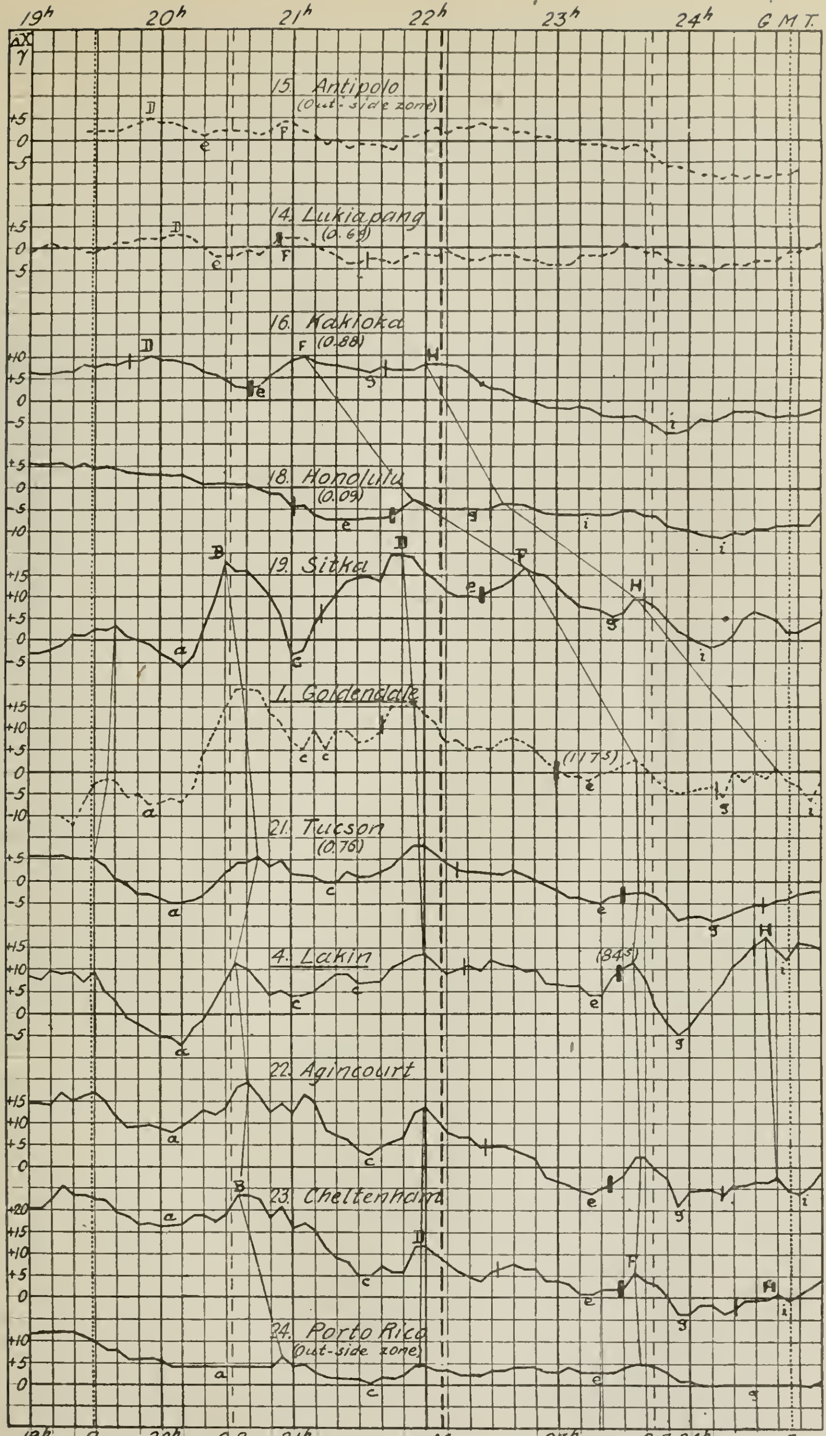

FIG. 15.—ΔX-Curves, Solar Eclipse, June 8, 1918.

68. *$\triangle Y$-curves* (*Fig. 16*).—The conclusions to be drawn are, in general, the same as those for the $\triangle D$ or $H\triangle D$ curves (see paragraphs 42-49). It will be noted again that for the three stations west of the meridian of Honolulu, namely, Antipolo, Lukiapang and Kakioka, the effects (chief salient points) are in general the reverse of those for the stations east of the meridian of Honolulu (see paragraph 49). This fact is shown in Table 24, as well as in Fig. 16 by the horizontal line between Kakioka and Honolulu. The general facts with regard to the Greenwich civil mean times of the chief salient points are about the same as for the $\triangle X$-curves, as also the conclusions with respect to the average values of $\triangle Y$, regardless of sign, and the maximum ranges.

Table 24.—*Greenwich mean times of chief salient points of $\triangle Y$-curves, as also the average effects, regardless of sign, and maximum ranges for June 8, 1918.*

Station	a	B	c	D	e	F	g	H	i	Terr. Ecl. Interval		Loc. Ecl. Interval	
	19^h	20^h	20^h	21^h	21^h	22^h	23^h	23^h	24^h	Av. Ef.	Range	Av. Ef.	Range
	m	m	m	m	m	m	m	m	m	γ	γ	γ	γ
Antipolo	.....	+02	+57	+10	+55	.....	.....	+ 58	+35	......	......	......	......
Lukiapang	+35	+05	+40	+05	+55	+90	+42	+ 60	.....	......	......	......	......
Kakioka	+35	+12	+42	+05	+55	+85	+35	+ 55	+28	3.0	18	2.6	11
Honolulu	+35	+20	+30	00	.....	.....	.....	+102	.....	2.7	15	1.3	5
Sitka	+65	+45	+60	+10	+24[1]	+19[1]	+15	+ 38	+07[1]	4.7	28	5.4	11
Goldendale	+52[1]	+45	+55	+15[1]	+35	+40	+45	+ 80	.....	7.4	16	4.7	7
Tucson	+55[1]	+25[1]	+45	+18	+70	+80	+50	+ 90	.....	4.0	11	6.3	8
Lakin	+45	+20	+50	+25	+60	+92	+55	+ 95	.....	3.7	15	3.9	13
Agincourt	+30	+15	+40[1]	+10	+55	+100	+50	+ 83	.....	3.8	17	2.6	10
Cheltenham	+35	+15	+40	+10	+57	.....	.....	+ 95	.....	4.8	22	2.1	6
Porto Rico	.....	+30	+45	+15	.....	.....	.....	+ 90	.....	......	......	......	......
									Means	4.3	17.8	3.6	8.9

[1]Mean of two or more points.

69. *$\triangle Z$-curves* (*Fig. 14*).—While the $\triangle Z$-quantities are not in general as certain as the $\triangle X$'s, or the $\triangle Y$'s, such conclusions as may be drawn safely from the curves and Table 25 are in general accord with those already deduced. It will be seen that the average values of $\triangle Z$, regardless of sign, are about the same for

Table 25.—*Greenwich mean times of chief salient points of $\triangle Z$-curves, as also average effects, regardless of sign, and maximum ranges for June 8, 1918.*

Station	a	B	c	D	e	F	g	Terr. Ecl. Interval		Loc. Ecl. Interval	
	20^h	20^h	21^h	21^h	21^h	22^h	24^h	Av. Ef.	Range	Av. Ef.	Range
	m	m	m	m	m	m	m	γ	γ	γ	γ
Antipolo	......	+70	+30	......	......	+ 69[1]	......	......	......	......	......
Lukiapang	+22	+55	+10	+ 60	+ 72	+ 98	......	......	......	......	......
Kakioka	+07	+47	+05	+ 30	+ 56[1]	+ 50	00	12.6	12	10.2	5
Honolulu	+15	......	......	+ 70	+ 97	+ 70[1]	15[1]	2.1	9	1.4	5
Sitka	+30	+70	+20	+ 72	+105	+130[1]	35	24.0	12	23.3	8
Tucson	+44[1]	+92	+57	+ 87	+ 95	+120	43[1]	4.4	6	3.4	3
Lakin	+50	+85	+35	+110	+140[1]	+140	35[1]	24.0	20	28.0	11
Agincourt	+68	+82	+68	+135	+152	+128	......	7.7	8	9.9	3
Cheltenham	+70	+95	+75	......	......	+115	......	3.8	9	3.6	6
Porto Rico	+45	+75	+60	......	......	......	......	......	......	......	......
							Means	9.8	9.5	10.0	5.1

[1]Mean of two or more points.

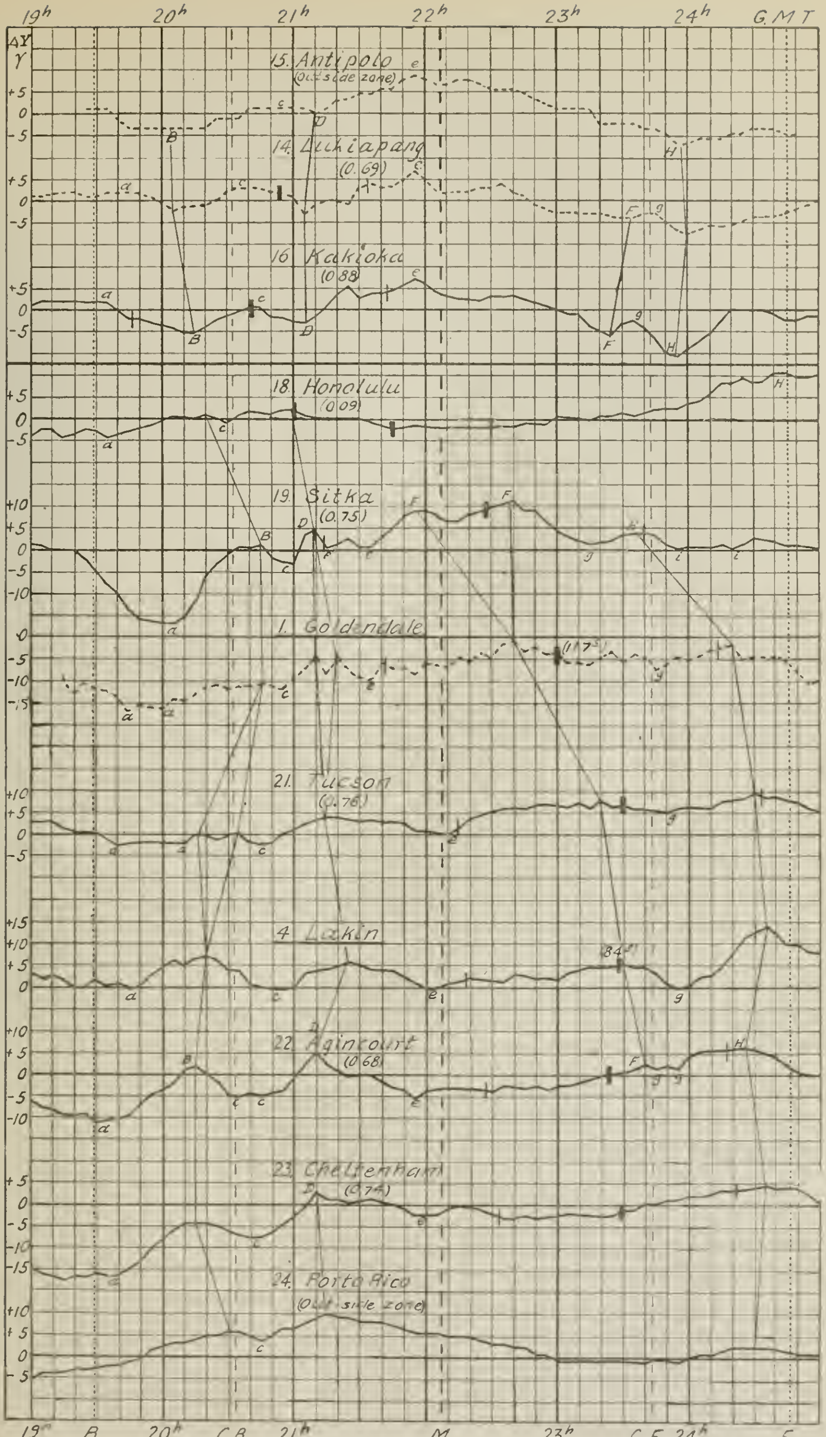

FIG. 16.—ΔY-Curves, Solar Eclipse, June 8, 1918.

the terrestrial eclipse-interval as for the local eclipse-interval, and that the maximum ranges for the entire interval ($19^h\ 29^m - 24^h\ 46^m$) are about twice those for the local eclipse interval.

Vector Diagrams for June 8, 1918.

70. With the aid of the values of $\triangle X$, $\triangle Y$ and $\triangle Z$, as given in Tables 19-22, the vector diagrams for certain typical stations were drawn for June 8, 1918, which diagrams, as compared with similar ones for the undisturbed days, presented interesting features. Fig. 17 is a reproduction of one of these diagrams, viz., the *XY-vector diagram for Kakioka*, Japan, June 8, 1918, from 19^h to 25^h, Greenwich civil mean time. The eclipse began at this station at $19^h\ 46^m$, which point is indicated in the diagram by the letter B; the middle (M) of the eclipse occurred at $20^h\ 41^m$, and the end (E) at $21^h\ 42^m$. It will be seen that from about $19^h.5$, when the eclipse began on the Earth, through to the points B, M, E, the curve is described in an anti-clockwise direction, or in the reverse direction to that for an undisturbed day. The anti-clockwise motion continues until about $22^h\ 15^m$, when the normal or clockwise motion is pursued until about $23^h\ 05^m$; the motion then becomes complicated, being partly clockwise and partly anti-clockwise.

Similarly the YZ-diagram at Kakioka on June 8, 1918, during the terrestrial eclipse-interval consists of a number of loops and reversals, and is exceedingly complicated, indeed, as compared with that for an undisturbed day. The same remarks may be made on the XZ-diagram of June 8, as also with regard to the DI-curve described on June 8 by a freely-suspended magnetic needle, showing both the changes in the declination, D, and the inclination, I.

71. Fig. 18 is the *XY-vector diagram for Cheltenham* on June 8, 1918. It will be seen that instead of a straightforward motion during the terrestrial eclipse-interval, loops are repeatedly described which are especially numerous during the period the eclipse occurs in North America; the period of the eclipse at Cheltenham is indicated on the curve by the letters B, M and E. Similar remarks may be made with regard to the vector diagrams of the other components, as also with respect to the curve described by a freely-suspended needle at Cheltenham on June 8, 1918.

72. The various diagrams for *Lakin*, where the eclipse was total, are all very complicated as compared with similar diagrams for undisturbed days.

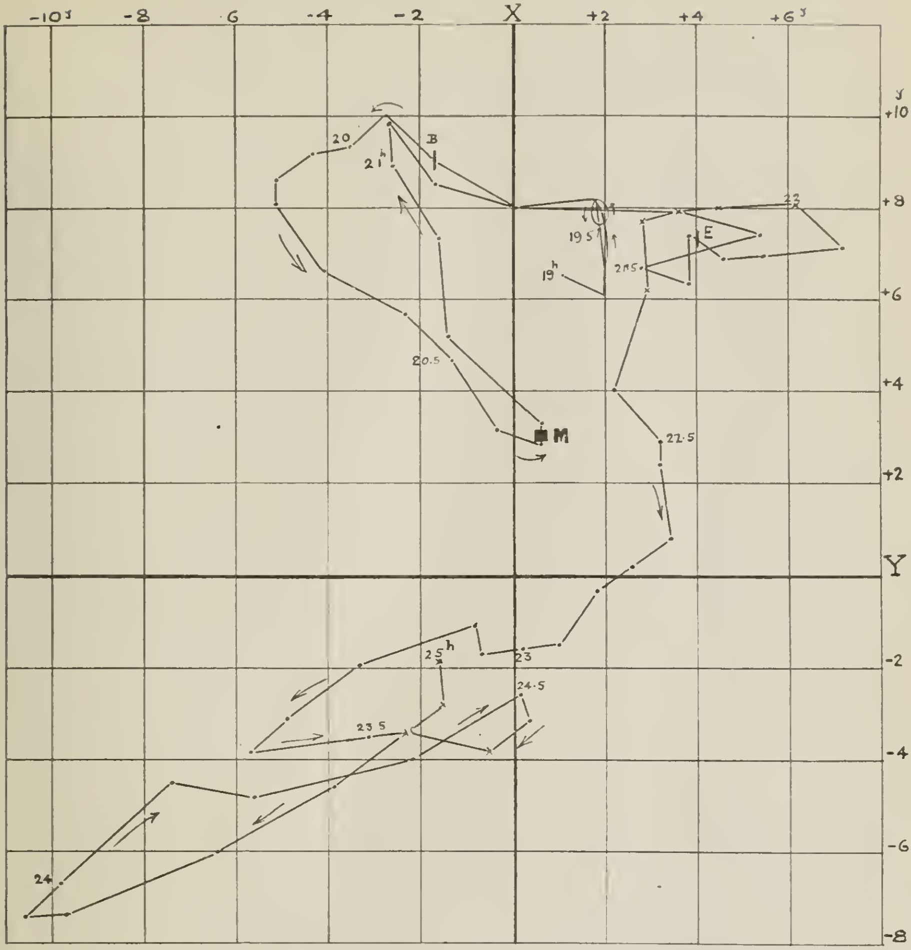

FIG. 17.—XY-Vector Diagram, Kakioka, June 8, 1918.

73. The facts revealed by the vector diagrams of June 8, 1918, are in general agreement with those found for previous eclipses,[1] namely, that, *in general, during the period of a solar eclipse, the directions in which the vector diagrams are described are either very complicated or are the reverse of those for an undisturbed day during day-hours. The reversals and loops during an eclipse are usually similar to those which occur, for example, on an undisturbed day near midnight.*

[1]See *Terr. Mag.*, vol. 5, p. 157, 1900; vol. 7, p. 179, 1902; vol. 21, p. 86, 1916.

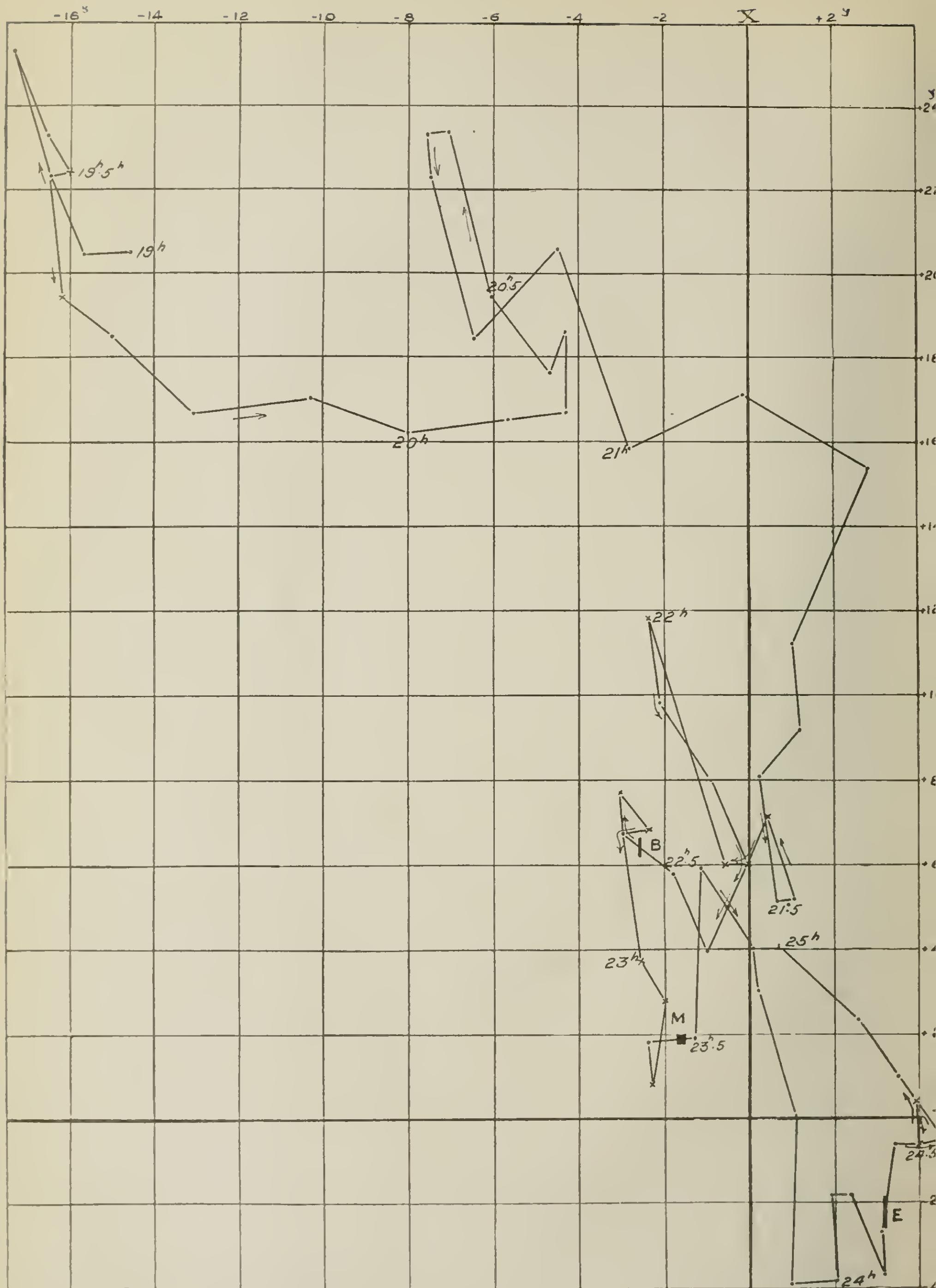

FIG. 18.—XY-Vector Diagram, Cheltenham, June 8, 1918

Comparison of Solar-Diurnal Magnetic Variation and Eclipse Magnetic Variation.

74. Quoting from L. A. Bauer's article[1] on the results of the eclipse magnetic observations of May 28, 1900 and May 18, 1901:

"Let us suppose that the magnitude of the effect produced on any one magnetic element, as for example, the range of the declination variation, be directly proportional to the amount of sunlight a body is able to cut off from our atmosphere. Since the Earth and Moon are practically at the same distance from the Sun, we may say that the amount of sunlight these bodies cut off will approximately be to each other as the squares of their diameters, i. e., as $(3.67)^2$:1 or as 13.5:1."

Preliminary tests of this hypothesis with the aid of the data at the time available gave the following results:[2]

Table 26.—*Preliminary comparison of solar-diurnal variation and eclipse variation of the magnetic declination for the solar eclipses of 1871, 1900 and 1901.*

Station	Eclipse	Declination: d_s=solar diurnal range	Declination: d_e=solar eclipse range, Computed	Declination: d_e=solar eclipse range, Observed	d_e/d_s
		′	′	′	
Rocky Mount	May 28, 1900	10.8	0.8	0.9	0.08
Mauritius	May 18, 1901	6.6	0.5	0.6	0.09
Batavia	Dec. 12, 1871	6.0	0.4	0.7	0.12
		Mean			0.10

It will be seen that if d_s is the range of the solar-diurnal variation as determined from undisturbed days near the day of the eclipse, and d_e, the average range of the eclipse magnetic effect, the ratio, d_e/d_s, on the average for the 3 stations and 3 different eclipses, was 0.10. According to the hypothesis, the ratio should be $1/13.5=0.074$; thus the preliminary observational value (0.10) was of the right order of magnitude, though about 30% higher. The extensive data for the solar eclipse of June 8, 1918, afford further tests of the hypothesis.

75. The declination columns of Table 27 contain for various stations the values of d_s and d_e, for the solar eclipse of June 8,

[1] *Terr. Mag.*, vol. 7, p. 190, 1902.

[2] *Idem*, vol. 7, p. 191.

1918, as also those of d_E, the average range of $\triangle D$ for the terrestrial eclipse-interval ($19^h 29^m - 24^h 46^m$ G.M.T.). Next there are given the values of the ratios d_e/d_s and d_E/d_s. Weighting the ratios as shown in the last column, p, the weighted mean results are:

$$d_e/d_s = 0.077;\ d_E/d_s = 0.083;\ \text{mean ratio} = 0.08.$$

Thus the mean ratio, 0.08, does not differ materially from the hypothetical value, 0.074, though it is again a trifle larger.

76. A formula of the type[1]:

$$d = k \sec^2 \phi',$$

where ϕ' is the magnetic latitude, was found in general to give a satisfactory representation of the values of d_s, d_e and d_E. The only glaring departures (residuals) occurred for the stations, Meanook and Corona. For the former station (Meanook), which is the nearest station to the magnetic pole, the observed value d_s as derived from the 5 quiet days in June 1918 appears abnormally low. As regards Corona the interesting developments shown at this high mountain station were already pointed out in paragraphs 44-46. The value of ϕ' is derived from the formula, I being the magnetic inclination:

$$\tan \phi' = \tfrac{1}{2} \tan I.$$

A preliminary solution by the method of least squares gave the following formulae:

$$\begin{aligned} d_s &= 3.'90 \ \sec^2 \phi' \\ d_e &= 0.'292 \sec^2 \phi' \\ d_E &= 0.'332 \sec^2 \phi' \end{aligned}$$

From these formulae we get practically the same ratios for d_e/d_s and d_E/d_s as those in the previous paragraph.

A formula of the type[1], $d = k'/H^2$, where H is the horizontal intensity, yields practically the same results as that used above. (The reference at the end of paragraph 51 should have been to paragraph 75, not to 74.)

77. The horizontal-intensity columns of Table 27 contain the values of the average ranges h_s, h_e and h_E, as well as the ratios of

[1] See L. A. BAUER's article in *Terr. Mag.*, vol. 2, p. 70, 1897.

[1] See L. A. Bauer's article in *Terr. Mag.* vol. 2, p. 70, 1897.

TABLE 27.—*Ranges of solar-diurnal variation and of solar eclipse variation of the magnetic elements for June 8, 1918.*

Station	Declination					Hor. Intensity					Ver. Intensity					
	d_s	d_e	d_E	d_e/d_s	d_E/d_s	h_s	h_e	h_E	h_e/h_s	h_E/h_s	z_s	z_e	z_E	z_e/z_s	z_E/z_s	p
	′	′	′			γ	γ	γ			γ	γ	γ			
Antipolo[1]	3.4	...	0.50	.....	0.15	46	....	4.52	....	0.10	33	..	4.45	...	0.13	0.5
Lukiapang[2]	6.3	0.37	0.29	0.06	0.05	23	4.50	3.74	0.20	0.16	24	1.20	1.80	0.05	0.08	0.5
Kakioka[3]	6.6	0.51	0.69	0.08	0.10	17	4.80	4.47	0.28	0.26	13	2.75	3.13	0.21	0.24	1.0
Honolulu[4]	5.8	0.64	0.43	0.11	0.07	22	1.40	2.00	0.06	0.09	23	5.00	3.65	0.22	0.16	0.5
Sitka[4]	13.8	1.12	0.88	0.08	0.06	42	6.53	9.52	0.16	0.23	21	3.00	2.89	0.14	0.14	0.5
Goldendale[5]	[10]	0.78	0.81	0.08	0.08	[30]	4.48	5.90	0.15	0.20	..	....	....	....	....	0.5
Meanook	16.8	2.00	2.14	0.14	0.15	....	....	....	....	....	....	....	....	....	....	0.5
Corona[6]	[14]	1.37	1.59	0.10	0.11	....	....	....	....	....	....	....	....	....	..	0.5
Tucson[4]	8.5	0.48	0.56	0.06	0.07	17	3.15	3.95	0.19	0.23	26	0.70	0.98	0.03	0.04	1.0
Lakin[7]	11.5	0.64	0.71	0.06	0.06	29	7.90	7.40	0.27	0.26	30	4.25	3.88	0.14	0.13	1.0
Agincourt[8]	15.2	1.02	1.09	0.07	0.07	38	5.00	8.06	0.13	0.21	10	1.55	2.13	0.16	0.21	1.0
Cheltenham[4]	12.5	0.75	0.81	0.06	0.06	34	4.03	6.06	0.12	0.18	15	2.00	2.42	0.13	0.16	1.0
Porto Rico[4]	5.2	....	0.67	.....	0.13	19	....	2.44	.....	0.13	11	..	2.20	....	0.20	0.5
Weighted Means	......			0.077	0.083	.	.	. .	0.182	0.199	.	.	. .	0.135	0.151	

[1]Solar-diurnal ranges are for 5 quiet days in June 1911.

[2] " " " " " " " " " " 1913.

[3] " " " " " " " " " " 1913; when June data were missing, as was the case for *H*, the mean of May and July was taken.

[4]Solar-diurnal ranges are for 10 quiet days in June 1918.

[5] " " approximate; derived from other stations.

[6]Solar-diurnal range approximate; derived from observations June 7 and 9.

[7]Solar-diurnal range for *D* derived from 3 quiet days (June 7, 23, 24); for *H* and *Z* from June 7.

[8]Solar-diurnal ranges for 5 quiet days in June 1918.

h_e and h_E to h_s. The significance of the subscripts is the same as for the declination ranges. The weighted mean ratios are:

$$h_e / h_s = 0.182; \; h_E / h_s = 0.199; \text{ mean ratio} = 0.19.$$

Hence, the mean ratio of the average range of the eclipse horizontal-intensity effect to the range of the solar-diurnal variation of the horizontal intensity, as derived from the quiet days in June 1918, is about 2.5 times the hypothetical ratio referred to in paragraph 74.

78. The vertical-intensity columns of Table 27 contain similarly the average ranges for the vertical-intensity effects, namely, z_s , z_e and z_E, and the ratios. The weighted mean ratios are:

$$z_e / z_s = 0.135; \; z_E / z_s = 0.151; \text{ mean ratio} = 0.14.$$

Hence, the mean ratio of the average range of the eclipse vertical-intensity effect to the range of the solar diurnal variation of the vertical intensity, as derived from the quiet days in June 1918, is about 2 times the hypothetical ratio (0.074).

79. Before deriving the ranges of the eclipse magnetic variation contained in Table 27, 15-minute means, in order to smooth out accidental irregularities, were formed of the $\triangle D$'s in Table 9, of the $\triangle H$'s in Table 17 and of the $\triangle Z$'s in Table 19. The general conclusion to be drawn from paragraphs 75-78 is that *the declination effects of the eclipse variation are, on the average, slightly larger and the intensity effects about two times larger than would result on the hypothesis that the effect is directly proportional to the amount of sunlight cut off from our atmosphere by the Moon during an eclipse.*

PERIODS OF SOLAR-ECLIPSE MAGNETIC VARIATION, June 8, 1918.

80. Looking over the various curves in Figs. 13-16, it will be noticed that for the interval of observation there are a series of short waves, generally from three to four at any station. The average periods of these waves on June 8, 1918, are given in Table 28 for the effects $\triangle H$, $\triangle X$, $\triangle Y$ and $\triangle Z$ at various stations. The local eclipse-intervals are given in the last column. It will be seen from the mean quantities at the bottom of the table that *the average period-length of the short waves of the eclipse magnetic variation is about $1^h.3$, whereas the average length of the local eclipse interval is about 2^h.*

TABLE 28.—*Average short periods of eclipse magnetic variation, June 8, 1918.*

Station	△H	△X	△Y	△Z	Loc Ecl. Int.
	h m	h m	h m	h m	h m
Lukiapang	1 22	1 15	0 57	1 19	[1 20]
Kakioka	1 35	1 35	1 50	1 35	1 56
Honolulu	1 09	1 09	1 50	1 52	1 29
Sitka	1 03	1 03	0 54	1 18	2 27
Goldendale	0 55	0 55	1 04	....	2 31
Tucson	1 14	1 39	1 28	1 35	2 19
Lakin	1 06	1 06	1 28	1 15	2 12
Agincourt	1 19	1 19	1 34	1 35	1 48
Cheltenham	1 11	1 11	1 45	1 51	1 48
Means	1 13	1 15	1 26	1 32	1 59

In addition to the period of about $1^h.3$, there is *long period* clearly discernible in various curves of Figs. 13-16, the average length of which *is found to be $5^h.2$, or practically the same as the terrestrial eclipse-interval*, $5^h\ 17^m$ ($19^h 29^m - 24^h 46^m$ G.M.T.).

81. An examination of the magnetic effects as shown near the ends of the curves in Figs. 13-16, reveals the interesting fact that the eclipse magnetic variation does not completely cease at the end of the terrestrial eclipse-interval, viz., at 24^h46^m G.M.T. June 8, 1918, but continues for some time after. As judged by the extended curves for which data are at present available, *the magnetic effects continue an hour or more after the eclipse is over on the Earth.*

Preliminary Analysis of Solar-Eclipse Magnetic Variation.

82. A preliminary analysis of the solar-eclipse magnetic variation on June 8, 1918, indicates that the chief source of the effect must be ascribed to an electric system above the Earth's surface, supplemented by an internal system originating possibly as the result of induction by the outer system. The combined system is similar to that causing the solar-diurnal variation of the Earth's magnetic field in the respect that the magnetic poles are approximately east and west of each other; it is dissimilar in the respect that the solar-eclipse system, as it travels easterly over the Earth with the advancing shadow cone, causes, in general, the reverse of the magnetic effect arising from the system of the solar-diurnal variation, which may be supposed to move around the Earth in an east-west direction.

In the case of the solar-diurnal variation system we have a north-end attracting pole moving westerly towards a station in the Northern Hemisphere early in the morning, causing the easterly elongation of the declination-needle, followed by a south-end attracting pole, or north-end repelling pole, which causes in the early afternoon hours the westerly elongation of the needle. For the solar-eclipse variation system of June 8, 1918, on the other hand, we have, as the shadow-cone progresses, a north-end attracting pole moving *easterly* towards a station in the Northern Hemisphere, followed by a north-end repelling pole; hence, the reversed effects of the two systems.

83. The eclipse magnetic effects, other things being equal, are generally the same in character and not greatly different in magnitude at stations along the isochrone line of maximum obscuration for several hundred miles distant from the belt of totality.

A final analysis is deferred until the results from the observations to be made in connection with the solar eclipse of May 29, 1919, in the South Magnetic Hemisphere, are available.

Chief Conclusions for Part I (Magnetic Observations).

84. The following conclusions are drawn covering the chief results of the magnetic observations made in connection with the solar eclipse of June 8, 1918:

a. Appreciable magnetic effects were observed during the solar eclipse of June 8, 1918, at stations distributed over the entire zone of visibility and immediately outside. (How much further some of the effects may have extended must be left for future study.) The chief characteristics of the effects took place generally in accordance with the local eclipse circumstances and in general accord with effects observed during previous eclipses. The evidences of a direct relation between the magnetic effects and the solar eclipse are so numerous as to warrant drawing the definite conclusion that an appreciable variation in the Earth's magnetic field occurs during a solar eclipse. This particular variation is termed here the "solar-eclipse magnetic variation".

b. The range of the solar-eclipse magnetic variation, according to the particular magnetic element, is about 0.1 to 0.2 that caused by the solar-diurnal variation on undisturbed days. The effects are of a more or less complicated character, according to location of observation-station in the zone of visibility. The effects caused during the local eclipse-interval are superposed upon those caused by the continued disturbance of the Earth's magnetic field in the region over which the shadow-cone has already passed. It is thus possible to discern effects having a period approaching that of the local eclipse-interval and others having a period approximately that of the entire or terrestrial eclipse-interval.

c. The general character of the system causing the solar-eclipse magnetic variation is the reverse of that causing the day-light portion of the solar-diurnal magnetic variation. The range of the eclipse variation is comparable with that of the lunar-diurnal variation, and, like the latter, the variation usually consists of a double oscillation during its period of development.

d. The range of the apparent effect on the intensity of magnetization of the Earth during the solar-eclipse magnetic variation, is about equal to that found associated with a 10 percent change in the solar radiation as shown by changes in the solar-constant values.

e. The results at the high mountain-station, Corona, Colorado, indicate that the magnetic effects during a solar eclipse may be modified and even intensified by altitude of station, topography and meteorological conditions. In view of the bearing of these results upon the theory of the solar eclipse magnetic variation and possibly upon the theory of other variations of the Earth's magnetic field as well, it will be highly desirable in the planning of future eclipse work to include as many mountain-summit stations as conveniently possible.

Part II.—METEOROLOGICAL AND MISCELLANEOUS OBSERVATIONS

85. The General Scheme of Work, see paragraph 4, called for such meteorological observations as the observers found it convenient to include in their observational programs. It was suggested that, at least, the temperature be read every fifth minute (directly after the magnetic reading for that minute). As far as the United States was concerned more elaborate meteorological work was fully provided for by the United States Weather Bureau.

Temperatures Inside Observing Tents.

86. Table 29 contains the five-minute temperatures read with standardized thermometers inside a tent, or house, in connection with the magnetic readings at the field stations in North America. With the exception of the "outside" temperatures given for Corona in Table 30, the figures plotted in Fig. 19 do not represent the actual temperatures of the free or outside air; it should be remembered that, as was found necessary, a source of illumination of the magnet-scale was used, thus heating the air inside the observing tent or house. Nevertheless the temperature curves of Fig. 19 are of some interest in showing *relative* temperature-changes and the lag in the temperature-drop at totality, or at maximum obscuration; in general this temperature-lag inside the tents was from 5 to 10 minutes. It will be seen from an inspection of the two Corona curves (temperatures inside tent and in the open) that they run parallel courses, although the temperatures which they represent may differ considerably as to absolute amounts.

Meteorological Observations and Shadow Bands at Corona, Colorado.

87. The following is a report by Prof. E. Waite Elder, head of the physical laboratory of East Side High School of Denver, who was associated with L. A. Bauer's party at Corona. The site of the thermometer-shelter and the place where the shadow bands were observed by him during the eclipse were directly north of the magnetic station (see Fig. 4). For observing the shadow bands there was prepared a levelled space, about 8x9 feet and about 1 foot deep at the east end; the center of this space is 42 feet about north of the cross in the rock marking the magnetic station. The Fahrenheit thermometer used was loaned by Mr.

TABLE 29.—*Centigrade temperatures recorded at field stations during magnetic observations of June 8, 1918.*

Greenwich Mean Time	Goldendale	Green River	Corona	Lakin[1]	Mena	Brewton	Orlando	Berkeley	Lake Moraine	Urbana	Columbia	Austin	Washington[1]	Woburn	Rivière du Loup
h m	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
19 00	26.0	31.3	28.5	29.0	20.8	34.6	29.4	22.6	16.0	....	....	32.0	21.0	27.6	18.1
05	26.8	32.8	29.3	....	21.3	33.4	27.2	22.6	18.0	....	....	33.1	21.0	27.5	18.6
10	26.1	35.3	30.0	29.0	21.2	32.7	26.6	22.7	18.0	....	....	33.4	21.0	27.6	18.8
15	26.0	31.8	29.8	31.4	21.2	32.0	25.8	22.9	22.0	....	....	31.7	21.0	27.0	18.9
20	26.6	31.6	29.9	29.1	21.7	33.3	25.0	22.7	23.0	....	....	29.0	21.1	26.9	18.9
25	27.5	31.3	30.5	30.8	21.3	34.3	25.6	23.0	22.0	....	....	29.0	21.1	27.0	19.8
30	27.8	32.5	31.4	28.0	21.3	31.2	25.2	23.3	21.0	....	....	31.5	21.0	26.8	19.7
35	29.0	32.0	32.0	32.2	21.2	30.6	25.0	23.6	20.0	....	....	31 5	21.1	26.6	19.0
40	29.0	33.0	31.8	29.2	21.3	30.7	25.2	23.4	17.0	....	....	33.0	21.1	26.2	18.1
45	29.0	32.3	30.1	29.2	21.5	30.1	27.0	23.6	16.0	....	....	31.0	21.2	26.6	17.2
50	28.0	33.5	28.2	31.9	21.7	29.9	28.1	23.2	16.5	....	....	33.2	21.3	26.8	17.8
55	29.0	34.8	26.5	29.9	21.5	29.8	29.2	23.0	16.0	....	....	33.8	21.5	26.7	18.2
20 00	29.2	33.2	24.8	34.2	21.4	29.4	29.3	23.0	15.0	....	31.2	34.2	21.6	27.0	18.5
05	28.7	34.4	23.8	33.4	21.5	29.1	31.0	23.0	15.2	....	32.2	34.7	21.8	26.6	18.1
10	28.7	34.9	21.1	33.3	21.7	29.0	30.6	23.2	15.2	....	32.8	35.1	21.8	26.2	17.7
15	28.4	35.0	19.7	30.0	21.8	28.9	30.0	23.6	16.0	....	33.2	34.0	21.5	26.2	17.9
20	29.0	36.6	17.7	33.4	21.8	28.7	28.9	24.1	17.0	....	34.2	33.4	21.6	25.7	17.9
25	28.2	33.2	15.9	34.1	22.1	28.7	29.3	24.5	15.6	....	34.6	35.5	21.7	25.5	17.6
30	29.1	33.0	14.6	33.2	21.8	28.4	29.0	24.0	15.0	....	32.2	35.2	21.8	25.6	17.8
35	28.0	33.8	13.8	32.8	21.8	28.4	29.0	24.3	16.0	....	31.3	35.7	21.7	26.0	17.9
40	28.2	34.0	14.6	33.8	21.8	28.2	28.0	24.5	18.8	....	30.4	35.5	21.6	26.3	17.8
45	27.8	34.2	16.7	32.2	21.7	26.4	28.0	24.7	19.0	....	30.2	35.6	21.7	26.4	17.8
50	28.5	35.5	18.0	33.9	21.8	26.0	27.5	25.0	17.2	....	30.8	36.0	21.6	26.0	17.5
55	28.2	34.2	18.0	30.5	22.0	25.8	26.7	24.7	15.5	....	33.7	35.0	21.6	26.1	17.0
21 00	28.0	32.1	18.0	31.7	....	25.7	27.0	25.0	14.5	....	32.2	35.0	21.5	26.0	17.2
05	28.0	33.2	18.8	31.3	21.6	25.4	27.0	25.3	13.5	....	31.6	34.8	21.3	25.9	17.0
10	27.5	34.1	20 8	32.0	22.0	25.4	27.1	25.7	12.0	....	32.5	35.6	21.3	25.7	17.0
15	28.6	36.0	21.9	31.6	21.8	25.2	27.7	25.7	10.5	....	31.0	36.2	21.5	25.4	14.6
20	27.8	37.3	21.1	31.8	21.9	25.0	27.2	25.0	9.0	....	30.0	36.5	21.6	25.4	14.7
25	28.1	34.4	20.2	30.5	21.9	25.2	27.0	24.8	8.3	....	30.0	36.0	21.8	25.6	14.7
30	28.0	35.3	19.3	29.3	22.0	25.4	27.0	25.1	7.8	....	29.9	36.4	21.7	25.8	15.1
35	29.0	34.4	18.3	29.3	22.2	25.3	27.0	24.8	8.0	....	29.3	36.2	21.8	25.6	15.2
40	30.0	28.8	17.2	30.2	22.3	25.0	27.1	24.7	8.0	....	29.2	36.6	21.9	25.7	16.2
45	29.3	35.4	16.4	31.2	22.7	25.1	27.2	24.7	7.2	....	29.5	37.0	21.9	25.8	15.8
50	28.6	33.5	15.7	31.2	22.9	25.2	27.0	25.2	7.5	....	30.2	35.4	21.8	25.4	16.0
55	30.0	33.8	15.1	29.8	23.0	25.0	27.0	25.2	7.6	....	30.0	36.0	21.8	25.1	16.0
22 00	29.0	34.2	14.8	29.4	23.1	25.1	27.0	24.9	7.5	....	31.4	34.4	21.5	25.0	16.0
05	28.5	32.0	14.5	29.8	23.2	25.0	27.0	24.2	7.5	....	30.3	36.0	21.5	25.1	[16.0]
10	28.0	28.2	14.6	30.1	23.3	25.0	27.0	24.2	7.2	....	31.8	36.5	21.5	24.7	16.0
15	28.0	27.8	14.7	29.5	23 6	24.8	26.9	24.6	7.8	....	31.6	37.0	21.9	24.2	16.2
20	28 0	34.5	15.2	28.2	23.8	24.8	26.5	24.2	8.0	30.0	32.2	37.0	21.9	24.2	16.0
25	28.0	31.8	15.8	29.2	23.8	24.9	25.8	23.6	8.3	30.0	30.8	36.9	21.9	24.2	15.0
30	28.3	32.6	16.1	29.2	24.1	24.9	25.6	23.5	8.0	29.9	31.3	36.2	21.6	24.0	14.3
35	27.7	32.6	16.7	28.7	24.2	24.9	25.8	23.0	8.2	29.3	32.3	36.3	21.7	23.5	14.7
40	27.0	29.8	17.1	26.8	24.2	24.7	25.8	22.8	8.2	29.0	31.2	36.6	21.7	23.3	14.8
45	27.0	28.5	17.5	26.9	23.9	24.4	26.8	22.7	8.2	28.8	31.0	37.0	21.4	23.1	14.8
50	26.6	27.4	17.9	27.0	23.2	24.3	28.0	22.2	9.0	28.6	30.0	37.2	21.3	22.6	14.9
55	26.0	26.8	18.1	26.8	23.4	24.6	26.8	22.0	9.0	28.4	29.8	36.2	21.4	22.1	14.1
23 00	26.0	27.0	18.1	25.7	23.1	24.2	25.4	22.0	9.1	27.8	30.2	36.0	21.0	21.9	14.1
05	25.0	28.1	18.0	25.1	23.1	....	25.6	22.1	9.2	27.2	29.8	35.0	21.9	21.4	13.9
10	25.0	27.9	17.5	24.7	23.0	24.1	25.7	21.7	9.2	26.8	29.7	34.6	21.8	20.8	14.0
15	25.6	27.8	16.8	23.7	22.8	24.0	25.1	21.6	9.0	26.0	27.8	34.2	21.9	20.0	13.9
20	25.8	25.9	15.9	23.0	22.7	23.9	25.0	21.5	8.8	25 1	27.7	33.4	22.0	19.5	13.9
25	26 0	25.2	15.0	22.7	22.8	24.0	25.0	21.2	....	24.8	27.3	33.0	22.0	18.9	13.9
30	26.2	25.2	14.1	22.1	22.5	24.0	25.0	21.4	9.0	24.0	26.6	32.0	21.9	18.6	13.8
35	26.9	25.7	13.6	22.0	22.3	24.0	25.0	21.6	9.4	23.5	26.5	31.8	21.9	18.0	13.8
40	27.0	25.8	13.0	22.1	22.4	....	25.0	21.7	9.2	23.7	26.7	31.8	21.9	17.5	13.7
45	27 0	26.0	12.9	22.4	22.6	23.7	25.0	22.1	9.0	23.0	26.8	31.8	21.6	17.2	13.4
50	27.3	26.5	12.6	22 8	22.7	24.0	25.1	22 0	9.1	23.0	26.8	31.8	21.5	17.0	13.2
55	27.6	26.9	12.6	23.0	22.5	24.3	25.1	21.7	8.2	23.0	26.9	31.6	21.4	16.6	13.5
24 00	27.5	27.0	12.8	23.2	22.1	24.2	25.0	21.6	8.0	23.2	27.3	31.6	21.4	16.2	13.5
05	27.1	27.3	12.8	23.6	22.0	23.8	25.0	21.8	8.0	23 3	27.4	31.7	21.3	15.8	13.8
10	27.2	27.5	12.9	23.7	21.9	23.6	25.0	21.9	8.0	23.3	27.7	31.6	21.3	15.2	13.8
15	27 5	28 0	12.8	23.6	21.8	23.6	25.2	22.3	8.8	23.6	27.3	31.5	21.2	14.9	13.7
20	27.7	28.3	12.8	24.2	21.8	24.0	....	23.0	9.2	23.8	27.7	31.3	21.1	14.7	13.7
25	28.0	28.0	12.2	24.2	21.9	23.9	....	23 0	8.0	23.7	27.6	30.8	21.1	14.3	13.7
30	28 1	27.1	12.0	24.0	21.8	23.9	....	23.2	7.6	23.4	27.4	30.8	21.0	14.0	13.5
35	29.0	27.8	12.0	23.8	21.7	23.9	....	23.2	8.2	23.0	27.2	30.6	21.0	13.7	13.2
40	29.3	27.9	12.2	23.4	21.7	23.9	....	23.0	9.1	22.7	27.2	30.6	21.0	13.2	13.5
45	29 6	27 6	12.3	22.9	21.8	23 8	....	22.7	8.8	....	26.9	30.5	21.0	13.0	13.5
50	29.4	27.5	12.4	22.4	21.8	23.8	....	22.7	9.0	21.8	27.8	30.4	20.8	13.0	13.6
55	29.0	27.4	12.9	22.5	21.7	23 6	....	22.8	9.0	21.2	26.4	30.0	20.6	12.5	13.6
25 00	29.0	26.7	13.5	22.3	21.6	23.7	....	22.8	9.0	....	26.3	29.7	20.6	12.0	13 6

[1]Lakin and Washington readings were mostly 2 minutes earlier than 5-minute readings.

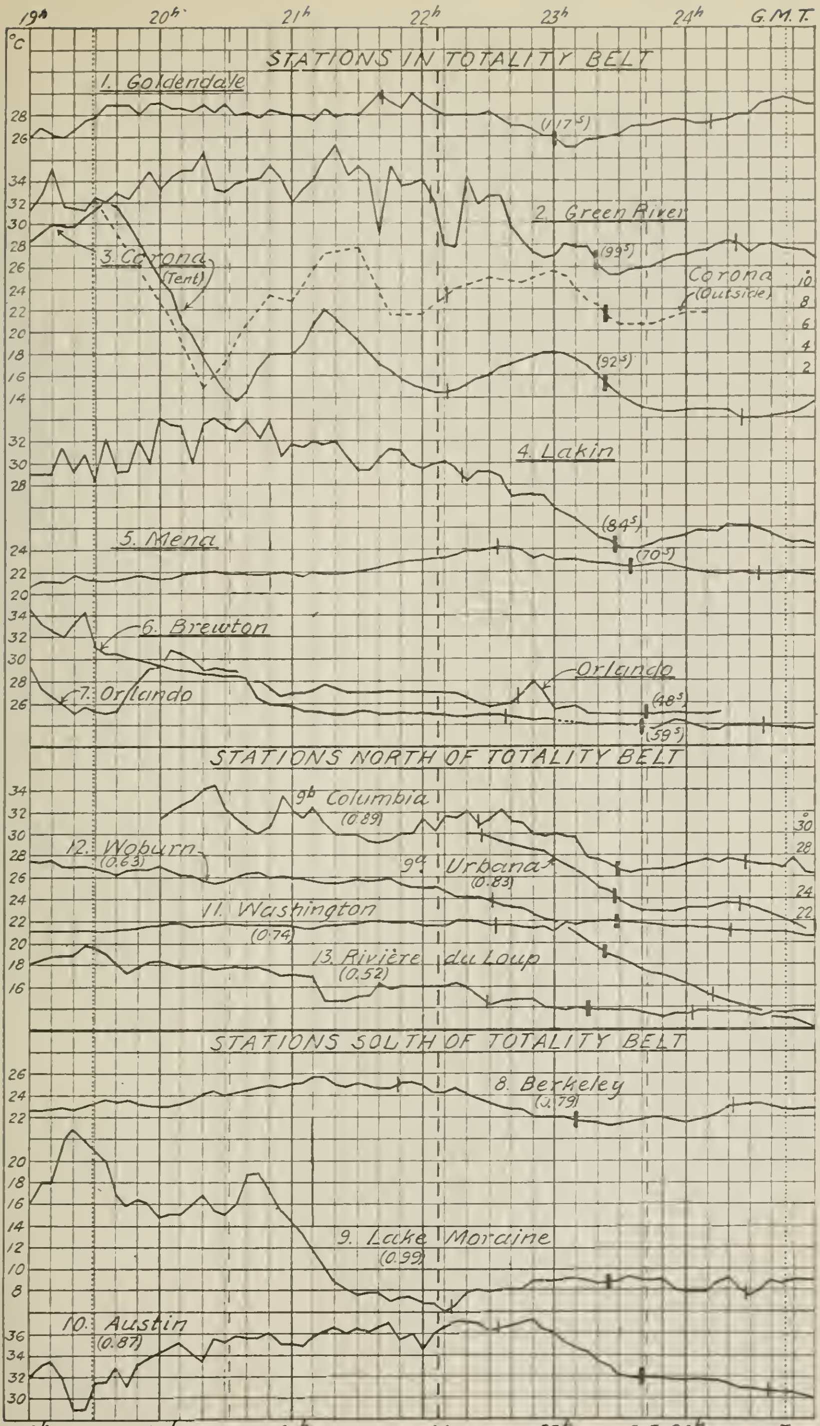

FIG. 19.—Temperature Curves, Solar Eclipse, June 8, 1918

A. L. Britt, telegraph operator at Corona; it was compared with standardized C. I. W. centigrade thermometer No. 6722 and the recorded temperatures were thus reduced to standard. Plate I, Fig. 1 will give some idea of the prevalent meteorological conditions near time of totality; see also paragraph 9.

Prof. Elder used a watch for noting the times, the correction of which on Greenwich mean time was controlled by means of the time signals received at Corona on June 7, 8 and 9.

Table 30.—*Meteorological Observations and Shadow Bands at Corona, June 8, 1918.*

G.M.T.	L.M.T.	Corrected Temp.		Remarks
		Fahr.	Cent.	
h m	h m	°	°	
19 30	12 27	64.5	18.1	Cloudy; wind from N.
20 03	13 00	44.8	7.1	Raining
20 20	13 17	33.6	0.9	Snowing
20 30	13 27	37.7	3.2	Snow stopping
20 40	13 37	43.8	6.6	Sun shining
20 50	13 47	48.9	9.4	Cloudy
21 00	13 57	47.9	8.8	Clearing
21 15	14 12	55.9	13.3	Clouding
21 30	14 27	56.9	13.8	Cloudy
21 45	14 42	45.9	7.7	Cloudy; snowing a little
22 00	14 57	45.9	7.7	Cloudy
22 15	15 12	49.9	10.0	Sun barely showing
22 32	15 29	51.9	11.1	Clouds thinning
22 45	15 42	50.9	10.5	Clouds thinning; light wind from South at surface; thin clouds over Sun drifting slowly eastward.
23 00	15 57	52.9	11.6	Clouds still thinning
23 05	16 02	51.9	11.1	Shadow of Moon shows tubular form in clouds
23 10	16 07	49.9	10.0	Sun very clear; no wind at surface; clouds drift S. W.
23 15	16 12	47.9	8.8	Cloud over Sun
23 18	16 15	....	....	Halo color 5° S. E.
23 19	16 16	....	....	Halo south of Sun in clouds; clouds thinner
23 20	16 17	46.9	8.3	Halo 3° N. of Sun
23 21	16 18	....	....	Clouds beautifully bordered with color
23 23	16 20	45.9	7.7	Had to use match to read thermometer. Too cloudy to see *shadow bands* at beginning of totality; *shadow bands* about 10 cm. wide and 20 cm. apart
23 25	16 22	44.9	7.2	Brisk wind from N. W.; at end of totality, *shadow bands* 15° N. of E. traveling 2.5 to 3 m. per sec., toward S. E. by S.
23 30	16 27	43.9	6.6	
23 35	16 32	43.9	6.6	Clouds thin
23 40	16 37	43.9	6.6	
23 45	16 42	43.9	6.6	
24 00	16 57	45.9	7.7	
24 10	17 07	45.9	7.7	

Some Astronomical Observations at Corona, Colorado.

88. The following is a report by Mr. A. L. Britt, in charge at the time of the Western Union Telegraph office at the Denver and Salt Lake R. R. station, Corona, Colorado. Mr. Britt had just purchased a 3.5 inch refracting telescope, and kindly volunteered to put at our disposal any observations he might obtain. He selected as his observation-point the summit of the mountain on the side of which the magnetic station was located. His location was about ¼ mile east of the magnetic station (see Fig. 4), and several hundred feet higher, making his altitude above sea-level about 13,000 feet.

Location.—Windy Point, about one-half mile east of Corona station, Colorado, on the Denver and Salt Lake Railroad.

Weather.—Part cloudy.

Instrument used.—3.5-inch refractor, using 100-power eye-piece.

Remarks.—The first and second contacts were obscured by clouds, but the Sun cleared about 15 seconds after second contact, and the total phase was visible from that time until third contact under fair to favorable conditions. The last contact was obscured by clouds. The Sun was visible under varying conditions of favorableness for a total period of approximately one hour and thirty minutes.

Owing to a slight mistiness prevailing in the vicinity of the Sun during the total phase, the corona was not very brilliant and did not extend as far as the Moon's disc as it otherwise would under more favorable seeing. However, the apparent circular flow of the corona in the equatorial regions was fairly well defined.

Of the three red prominences noticed, the one on the Sun's north limb exhibited a peculiar curvature at its apex and, unlike the other two, seemed to be composed of two prominences near the base but it formed a junction about half-way out toward the point.

My efforts to detect the actual movement of the total shadow on the Earth's surface were to no avail, owing to cloudy condition of sky, I think, but I was able to note this movement on the clouds immediately after the total phase; the appearance of the shadow closely resembled a huge storm cloud, the resemblance being greatly enhanced by the part cloudy condition.

At the middle of totality the day-light circle, which was plainly visible in all directions from my vantage point, was a wonderful and inspiring spectacle. I regret that I did not have time to pay much attention to shadow bands on the surface, or make any measurements of same.

Corona, Colorado, June 12, 1918. A. L. Britt.

Part III.—ATMOSPHERIC-ELECTRIC OBSERVATIONS.

Atmospheric-Electric Observations at Lakin, Kansas.

89. It has been stated already in paragraph 10 that Lakin, Kansas, was the main station of the Department of Terrestrial Magnetism, and that complete magnetic and electric observations were made there. The results of the magnetic observations having already been given in Part I, it now remains to give an account of the atmospheric-electric work carried out during the period June 2 to 13 by S. J. Mauchly, assisted by A. Thomson and M. B. Smith. The electric observations comprised in general: potential-gradient, positive and negative conductivity, ionic content of positive sign, and penetrating radiation. At first the observations of potential-gradient and conductivity are reported upon in order that the main results will be accessible to those who may be planning to undertake similar work in connection with the solar eclipse of May 29, 1919.

Fig. 2[1] shows the location of Lakin in the belt of totality and Fig. 5 gives a view of the magnetic station. The geographic position of Lakin is: latitude, 37° 53′ N; longitude, 101° 18′ or $6^h\ 45^m$ W. The approximate local eclipse-circumstances, June 8, 1918, were:

Greenwich Civil Mean Time.			Totality.		
Beginning	Middle.	End.	Loc. M. T. Middle.	Magnitude.	Duration.
h m	h m	h m	h m		s
22 18	23 28	24 30	16 43	1.01	84

90. *Weather.*—During the forenoon of June 8, 1918, the sky was heavily overcast at Lakin. About noon all clouds disappeared except a fringe of cumulus near the horizon. Throughout the afternoon the dome of the heavens was free from clouds; although the fringe of clouds near the horizon persisted throughout the eclipse period, it was at all times much below the position of the Sun.

Potential-Gradient.

91. The station was located on a level and treeless plain to facilitate reduction of results to absolute values. The actual site was about 325 meters south of the magnetic observatory shown in Fig. 5 (*l. c.*). The method used for the potential-gradient observa-

[1] *Terr. Mag.* vol. 23, p. 97, 1918.

tions was that described by Simpson and Wright:[1] A wire about 25 meters long was supported about 95 centimeters from the ground by two posts 1 meter high from which it was insulated by two sulphur insulators. To the middle of this wire were attached two ionium collectors and one of its ends was connected to a Wulf electroscope.[2] The electroscope was located in a low sheltering hut several meters removed from one of the posts.

92. With this equipment it was easily possible to follow the short-period fluctuations of the potential-gradient. Control measurements were made on a number of days both before and after the day of the eclipse. Of these days, June 5, 6, 9, and 12 are comparable, as regards weather conditions, with the afternoon of June 8. On June 8, the observations were made by M. B. Smith at intervals of 2 minutes over a period of 6 hours, approximately central about totality. The results of the individual readings are given in Table 31, and are represented graphically in Fig. 20, where is also shown the mean potential-gradient curve for June 5, 6, 9, and 12.

93. It is instructive to consider the potential-gradient graphs of June 8 from two points of view:

(1) The rapid decrease in absolute value of gradient just preceding and during totality, the sharp minimum 6 minutes after mid-totality, and the persistence of a well-marked minimum for about 20 minutes after totality. This is almost identical with the findings of Julius Elster on the Algerian Coast in connection with the eclipse of May 28, 1900,[3] and is very similar to what was observed in 1905 by Elster and Geitel at Palma,[4] by Le Cadet at Tortosa in 1905,[5] and by Ludwig in India in 1898.[6] Striking variations from the above are Knoche and Laub's[7] failure to find *any* effect on the potential-gradient in Brazil during the 1912 eclipse and Nordmann's observation of an *increase* with obscuration culminating in a maximum 45 minutes after totality of the 1905 eclipse. Here it must be noted that the observations of Knoche and Laub correspond to an overclouded sky.

[1] G. C. SIMPSON and C. S. WRIGHT, *Proc. R. Soc.* A., vol. 85, p. 182, 1911.

[2] This electroscope was provided with an insulated subsidiary case, to which auxiliary potentials could be applied, and by means of which it was possible always to make the readings at maximum sensitivity, as also to keep the images of the fibers from going off the scale.

[3] *Phys. Zeit.*, vol. 2, p. 67, 1900.

[4] *Terr. Mag.*, vol. 11, p. 15, 1906.

[5] *Met. Zeit.*, vol. 41, p. 308, 1906.

[6] *Wiener Anzeiger*, p. 66, 1899; abstract in *Terr. Mag.*, vol. 4, p. 208, 1899.

[7] *Terr. Mag.*, vol 21, p. 203, 1916.

[8] *Met. Z. S.*, vol. 41, p. 306, 1906.

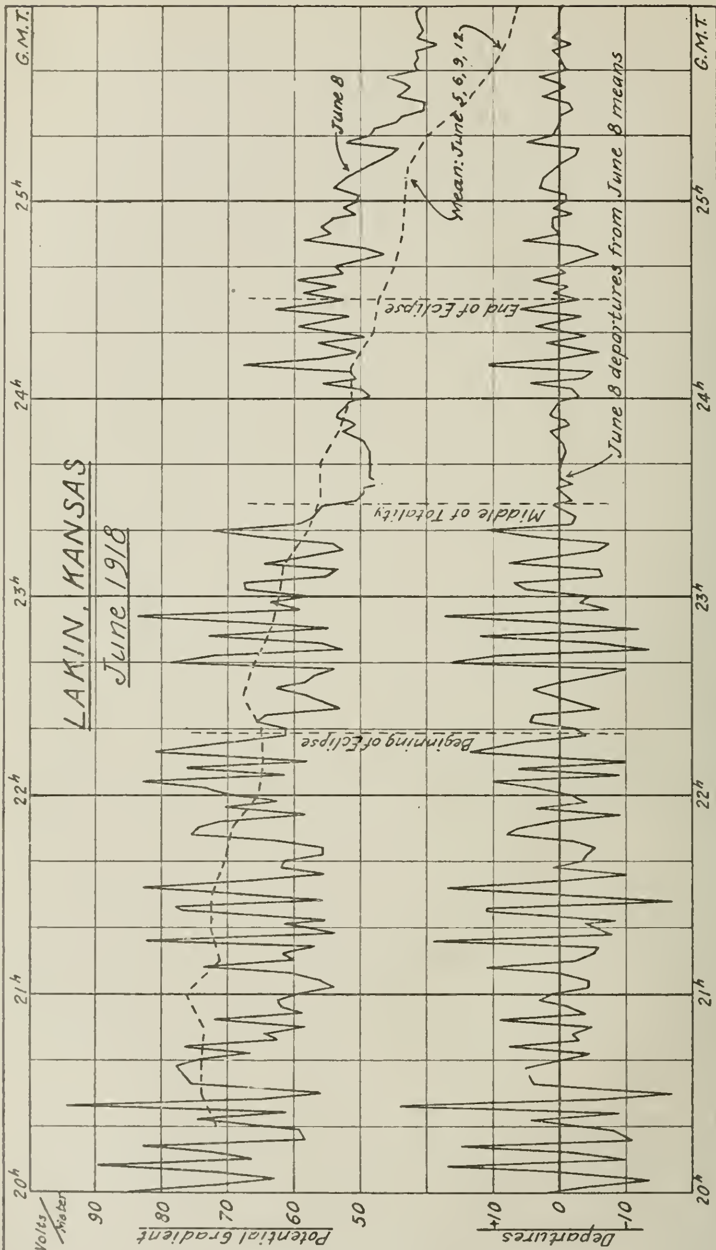

FIG. 20.—Variation of Potential-Gradient at Lakin for Solar Eclipse, June 8, 1918, and Mean Curve.

(2) Another interesting feature of the potential-gradient curve of June 8 is the well-marked diminution in the amplitude of the short period fluctuations observed just preceding, during, and for 20 minutes after totality. To separate this effect from the changes in absolute value, each of the individual potential-gradient observations of June 8 is compared with the mean of 5 observations having the same mean time and formed as follows: Observation 3 is compared with mean of observations 1, 2, 3, 4, and 5; observation 4 with mean of 2, 3, 4, 5, and 6, etc. The lower graph of Fig. 20 shows the departure of each observation from its own reference mean.

94. Not only does a much diminished amplitude accompany the minimum established during and shortly following totality, but both the absolute values and the amplitudes increase together with the disappearance of the eclipse. It is also noteworthy that with approaching sunset, which occurred at 2^h 03^m Greenwich civil mean time June 9, or 19^h 18^m local mean time June 8, the progress of both phenomena is very similar to that just preceding, during, and shortly after totality.[1]

Electrical Conductivity.

95. Conductivity observations were made for both λ_+ and λ_- at a station about 80 meters northeast of the potential-gradient station. In order to avoid making alternate observations for λ_+ and λ_- on a single instrument, a separate Gerdien conductivity apparatus was used for each sign. The crank-shaft of each apparatus was provided with a pulley; these pulleys were connected by belts to two larger pulleys on a jack-shaft so that both fans could be driven by one observer and at the same speed. Both instruments were covered by a skeleton roof 6 feet high, which provided shelter for observers and instruments, and prevented the conductivity results from being influenced by the potential-gradient. (See Fig. 23.)

96. Tests showed that determinations of λ could be made with an accuracy of 2 to 3 per cent during so short a period as 2 minutes, and, as frequent determinations were considered more desirable than high accuracy, the two-minute observation period was adopted. The observations on both instruments were made by the same observer, thus preventing the entrance of different personal errors into the λ_+ and λ_- results. The outer case of each

[1] Although attention appears not previously to have been directed thereto, we find evidence of the phenomenon of greatly dimished amplitude during totality and during about 20 minutes immediately thereafter in the photographic record obtained by Elster and Geitel in 1905. *Cf. Terr. Mag.*, vol. 11, p. 15, 1906.

apparatus was connected to earth and the initial potential-difference between inner and outer cylinders was between 57 and 58 volts. The jack-shaft was driven at a speed sufficient to keep the ordinary driving shafts of the instruments at 120 revolutions per minute.[1] With initial potential-difference and speed of fan as given above, Hewlett[2] at the Department of Terrestrial Magnetism found the results of the Gerdien conductivity apparatus to be "free from any error due to lack of ventilation." In general, after a set of 6 two-minute observations had been made on each instrument (total time requirement about 13 minutes) a calibration of the electroscopes was made and each instrument tested for leak. This procedure was followed throughout the afternoons of a number of days before and after the eclipse, and showed very satisfactory behavior of the instruments, while affording control data as well. On June 8, 20 consecutive two-minute observations were made on each instrument during 45 minutes symmetrical about totality. The June 8th conductivity observations were made by A. Thomson. The individual results are shown in Table 31, and together with mean values of λ_+ and λ_- for June 5, 6, 9, and 12, are represented graphically in Fig. 21.

97. It is seen that a large increase in both λ_+ and λ_- occurred just before totality, and that *both* continued abnormally large throughout the period (about 20 minutes) following totality and corresponding to the potential-gradient minimum. These graphs show no sign of a radically different effect for the two conductivities, such as has been suggested on the basis of some results which have been obtained by others. There is a dearth of reliable eclipse-data for conductivity, but Geitel (*l. c.*) found in Algeria on May 28, 1900, an increased conductivity for a considerable period following totality, and Le Cadet, in Spain (1905), concluded that the conductivity diminished with growing obscuration until totality, and then began to increase. However, Le Cadet's observations (*l. c.*) were made under unfavorable weather conditions. In this connection, it is of interest to note that for clouded sky and rain, Knoche and Laub (*l. c.*), in Brazil (1912), found diminution in both λ_+ and λ_- during and following the period of totality. Fig. 22 represents the total conductivity and the air-earth current-density, computed from total conductivity and potential-gradient, for June 8, and corresponding means for June 5, 6, 9, and 12.

[1] Corresponding to 2160 fan-revolutions per minute.

[2] *Cf. Ter. Mag.*, vol. 19, p. 136, 1914.

(*To be continued.*)

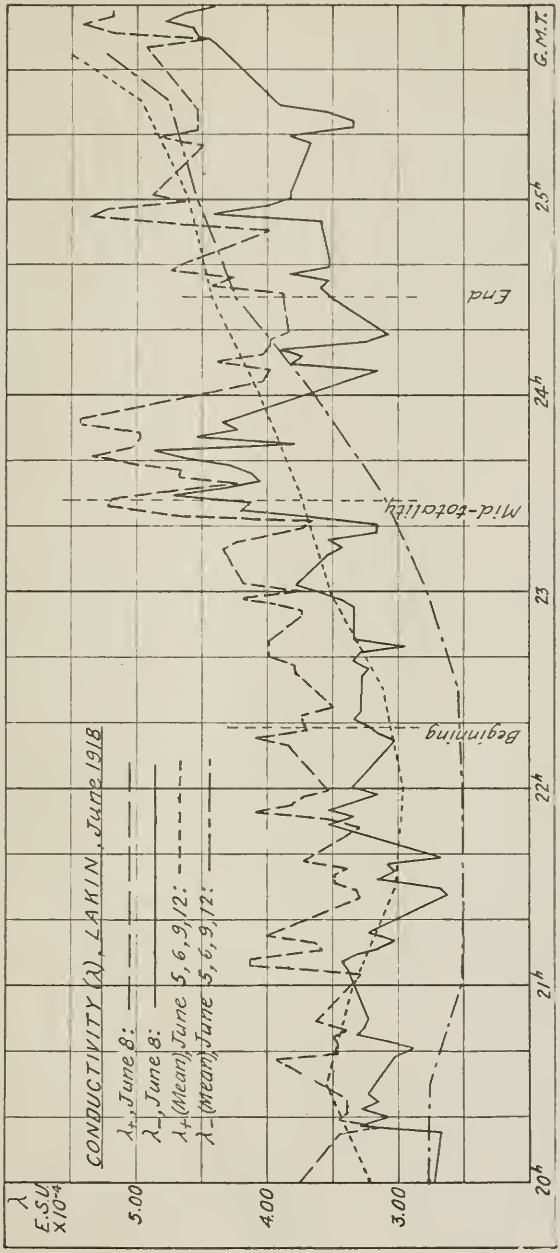

Fig. 21.—Variation of Positive and Negative Conductivities at Lakin for Solar Eclipse, June 8, 1918, and Mean Curves.

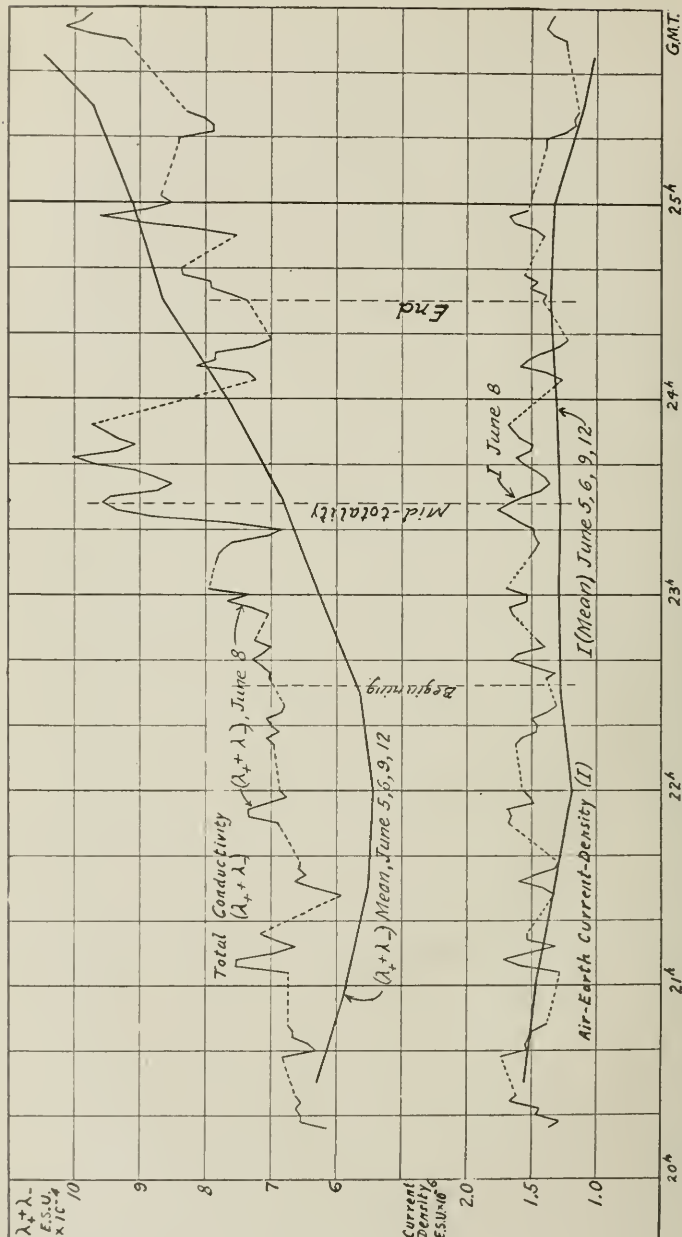

FIG. 22.—Variation of Total Conductivity and Air-Earth Current-Density at Lakin for Solar Eclipse, June 8, 1918, and Mean Curves.

NOTE ON A STRING GALVANOMETER FOR USE ON BOARD SHIP.

By J. A. Fleming.

The Department of Terrestrial Magnetism in connection with its ocean work and special duties assigned to it in 1917 has had occasion to design, with the assistance of Dr. W. F. G. Swann, a special form of string galvanometer, which was constructed in the instrument shop of the Department.

The galvanometer is of the string type originally developed by Prof. Einthoven. It is of the permanent-magnet, air-damped pattern. The magnetic field is produced by a laminated magnet consisting of five permanent horseshoe-magnets. These magnets are of the permanent magnet-steel supplied by the Crucible Steel Company of America, and were made following the methods used by the Department of Terrestrial Magnetism for the manufacture of magnetometer magnets.[1] To insure maximum flux-density in the gap, two pole pieces, P, of soft iron are attached as shown in the Section AB of Fig. 1; the gap for the fiber is 2 mm. wide.

The string element consists of a fine quartz fiber coated with silver or platinum; it is soldered to two cylindrical copper lugs which may be clamped in the standards S and S' (see Fig. 1). These standards are mounted on the plate K which in turn is mounted on the plate L by four adjusting sleeves and screws by which the plate K may be adjusted to center exactly the fiber in the gap. The tension of the fiber is regulated by means of the milled head Q which may be clamped in the screw sleeve R. The pitch of the latter is slightly different from that of the screw E which is mounted in the second standard S'. Because of the slight difference in the two pitches, it is possible to effect readily a fine adjustment of the fiber for tension. It should be noted that the standard S is fixed with reference to the plate K and that the standard S' is attached to a slide mounted between suitable clamps on the plate K. It is possible to alter quickly the distance between the two standards S and S' by unclamping the milled head Q and sliding the bar G with the standard S' one way or the other in the screw sleeve R. When the distance desired between the two standards is secured, the milled head Q is clamped and the final

[1] *Cf.* J. A. Fleming, "Two new types of magnetometers," *Terr. Mag.* vol. 16, pp. 2-3, 1911.

adjustment made. It is thus possible to use a fiber of any length between 93 mm. and 120 mm. In the present instrument the rod *G* is made of phosphor-bronze because invar-steel of proper size could not be obtained. For future instruments it is intended to use invar-steel in order to eliminate any possible effects due to the difference in temperature coefficients for the bronze rod and for the quartz fiber. Suitable cover plates and caps (see Fig. 2) are provided to exclude dust and air currents.

The small deflection of the fiber produced at right angles to the magnetic field by the passage of a current through the galvanometer is observed by projecting the image of the fiber on a glass scale by means of a beam of light passing through the microscopes M and M' and suitably mounted prisms (see Fig. 2 showing the microscopes but not the attachments for the prisms and scale). One of the microscopes serves as the optical condenser. The microscopes are mounted on adjustable carriers on either side of the central magnet-section, holes of suitable size being drilled through the section to permit the necessary adjustments of the objectives by the fine focusing arrangements. The diameter of these holes is 2 mm. greater than the diameter of the tube containing the objectives to permit centering of the microscope on the fiber; the free spaces about the objective tubes are packed with cotton when the instrument is in use.

The galvanometer is mounted in a frame (see Fig. 2) so arranged that it may be set up with the fiber either in a horizontal or a vertical position. The bearings of the axles supporting the magnets with their appurtenances are provided with two clamping screws so that the instrument may be clamped in any position in its bearings.

When used aboard ship it was found that vibrations, for example those from the engine, could be practically eliminated by suspending the galvanometer from the beams in the cabin with strong rubber bands.

The fibers are coated by the method described by Prof. H. B. Williams,[2] and the resistances range from 2000 ohms upward. Fibers of diameter 0.001 to 0.002 mm. are, on the whole, the most convenient.

Department of Terrestrial Magnetism,
Carnegie Institution of Washington.

[2] On the silvering of quartz fibers by the cathode spray, *Physic. Rev.* ser. 2, vol. 4, No. 6, pp. 517-521, 1914.

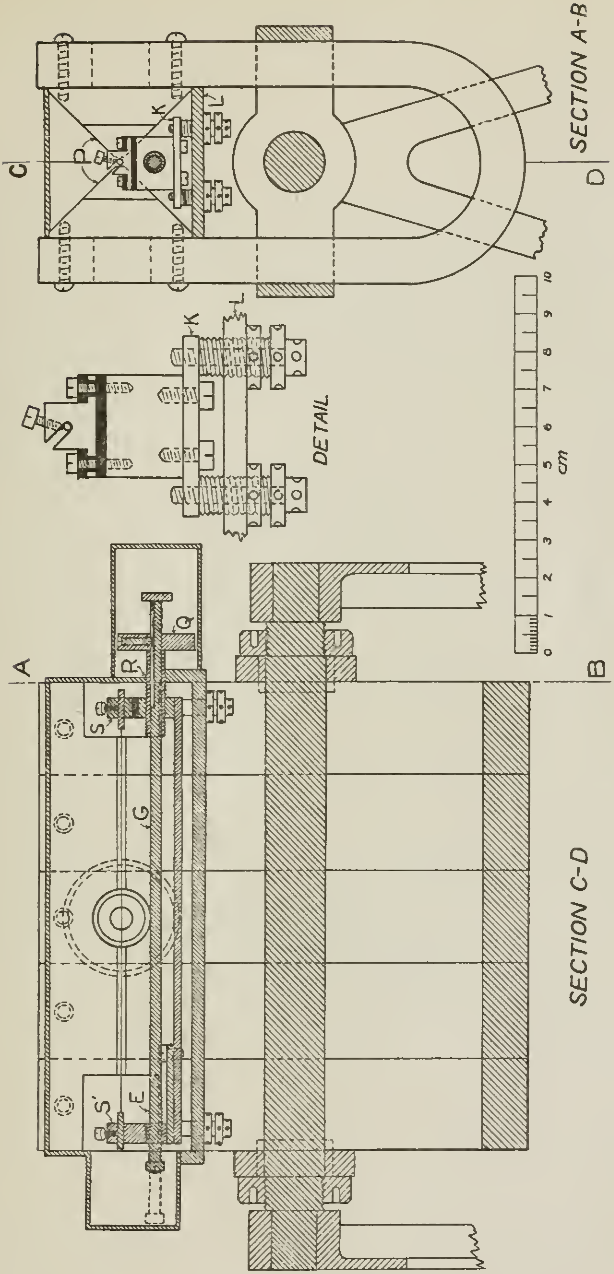

Fig. 1—Details of String Galvanometer for Ship Use.

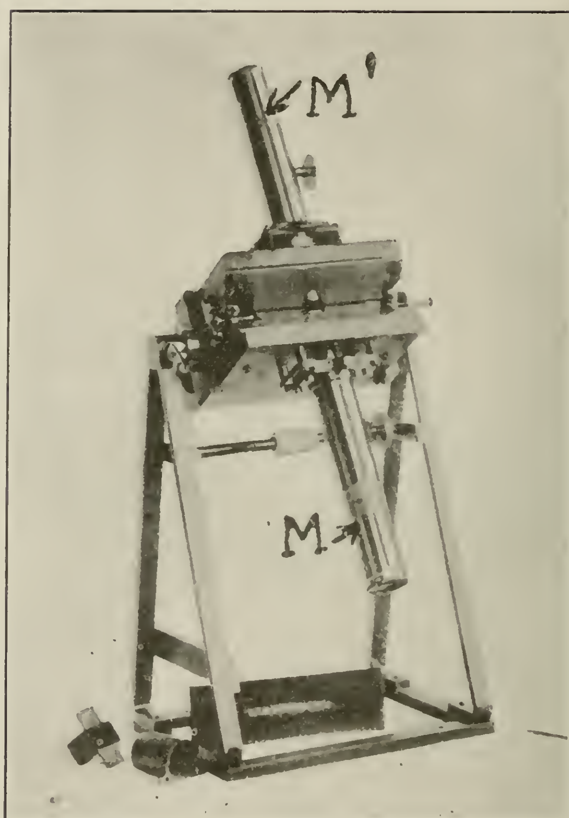

Fig. 2.—String Galvanometer.

SIMILARITIES BETWEEN THE EARTH CURRENT OBSERVED AT JERSEY, ENGLAND, AND AN ELECTRIC TIDE DERIVED FROM THE OCEAN TIDE.

By Marc Deschevrens, S. J.

In my second note[1] on the natural electric current observed *under ground* at Jersey, England, I showed that its diurnal variation obeyed a law similar to that which governs the ocean tide and that it may be concluded that there exists in the soil an electric tide which is the counterpart of the ocean tide. Pursuing further this interesting investigation, I have found that these two tides should be considered as related to each other even to such an extent that the first may be regarded as derived from the second. My opinion is based on the following points:

1. The two tides present a common form of diurnal variation which is not a double regular sinusoid, since the intervals of the phases are not equal.

Phase intervals of the two tides at Jersey, England.

	Min. to Max.	Max. to Min.	Min. to Max.	Max. to Min.
	h	h	h	h
Oceanic..........	5.7	6.7	5.7	6.7
Electric..........	7.4	5.0	7.3	5.3

The sea rises during 5.7 hours, and it falls during 6.7 hours; the electric current diminishes during 5.2 hours, and it increases during 7.3 hours.

Such inequalities are evidently not met with in the attractions of the Sun and Moon on the waters of the globe; they have their origin in the inertia of the waters, in their differences in depth, and in the irregularity of their distribution over the surface of the Earth. If the earth-electric current does not originate from the movements of the ocean-tide, how is the similarity of the intervals of phase in the two phenomena to be explained?

As the theory of the electric tide has not yet been developed, we must, for the present, accept the facts as they have been recorded and conclude that the electromotive force here in question decreases while the sea rises and increases during the ebb of the waters. There is, however, no coincidence between the time of high tide and the time of minimum electric current nor between the time of low tide and the time of maximum electric current.

[1] See *Terr. Mag.*, vol. 23, p. 145, 1918.

Mean differences of the corresponding phases of the two tides.

$$\begin{array}{l} \text{Electric tide: Min.} \\ \text{Oceanic tide: Max.} \end{array}\Big\} \, 1.98^{\mathrm{h}} \quad \begin{array}{l} \text{Max.} \\ \text{Min.} \end{array}\Big\} \, 0.95^{\mathrm{h}} \quad \begin{array}{l} \text{Min.} \\ \text{Max.} \end{array}\Big\} \, 2.00^{\mathrm{h}} \quad \begin{array}{l} \text{Max.} \\ \text{Min.} \end{array}\Big\} \, 0.38^{\mathrm{h}}$$

The corresponding phases of the current precede those of the ocean by a mean difference amounting to 1.33 hours.

This advance is easier to understand than the opposition of the phases. If the electromotive force is to be sought in the movement of the waters of the ocean, its greatest variation will accompany the greatest movements which naturally precede by some time the slack water of low and high tides.

2. The ocean tide, for the reasons which I have just stated, is normally later than the Moon. For a given port the retardation of high water with reference to the time of the Moon's meridian transit on the days of new and full moon is called the *establishment of the port;* for Jersey it is $6^{\mathrm{h}}\,25^{\mathrm{m}}$. If, in order to fix the establishment of the electric current it should be desired to refer to one of the two daily maxima, one would find, either $-0^{\mathrm{h}}\,40^{\mathrm{m}}$ since the first maximum is registered (almost an hour before noon), or $11^{\mathrm{h}}\,20^{\mathrm{m}}$ by the second maximum. Such an advance or such a retardation of the current seems equally inadmissible. We are thus again led to establish a special relation between the minimum of the electromotive force and the high sea.

3. From the observed retardations of the tide with reference to the Moon's transit it is known that the high water which follows the transit of the Moon on the day of new moon cannot be related to this transit but to a previous one and consequently this would not be the highest tide of the lunation. It is known that, on the average, the delay of the maximum effect of the conjunction of the Sun and Moon on the sea, is 36 hours; at Jersey, from the 12 lunations studied, I have found it to be about 40 hours for the ocean tide and 38 hours for the electric tide and here too, the greatest variation obtained is negative. It is therefore on the third day of the lunation when the greatest electric and oceanic tides are observed at Jersey.

There are given in Table 1 the harmonic coefficients of the variations of the electric current for the first days, in civil mean time, of the lunation (means of the 10 lunations from October 1917 to July 1918).

TABLE 1.—*The two principal waves of the solar electric tide at Jersey.*

	a_1	A_1	a_2	A_2
	°	V	°	V
1st day	240.9	0.0018	137.9	0.0060
2nd "	231.2	0.0017	115.5	0.0074
3rd "	238.7	0.0019	91.3	0.0087
4th "	249.0	0.0006	66.0	0.0073
5th "	258.0	0.0007	53.7	0.0065

The tide which is so well characterized here by the variation of the two coefficients of the semi-diurnal wave ($a_2 A_2$) is the solar tide, properly speaking, since the observations made have been distributed according to the solar hours and by days of 24 hours, a procedure which eliminates, at the end of the lunation, the variations due to the action of the Moon.

In order to obtain these latter variations, it is necessary to make another distribution of these same observations which furnish the detail of the total or composite tide, whence then by subtraction of the solar tide, one will get as remainder the lunar tide. This new distribution will consist of making the days of 25 or of 24 solar hours by beginning each of them with the observation made at the variable time of the Moon's transit.

But here it is necessary that the two tides have their greatest mean value and correspond well hour by hour. This may be done by taking the former tables and again transcribing the observations, beginning with that which shows the greatest effect of the conjunction of the two heavenly bodies. At Jersey, according to what I have said, this will be approximately 5^h in the morning of the third day of the lunation. We have thus the two tides beginning at the same instant, but the duration of the combined tide is one hour longer than that of the solar tide. A contraction of the first would reduce it to 24 terms instead of 25. When once this delicate operation has been accomplished by graphic procedure, the two series are in all respects comparable and one may proceed with the extraction of the lunar tide. A comparison of these three tides is given in Table 2; see also Figs. 1 and 2.

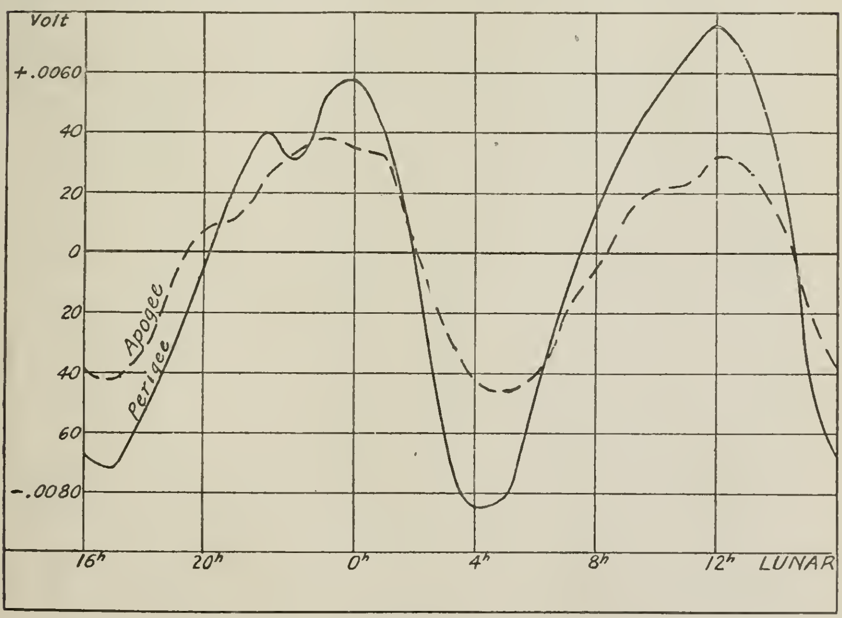

FIG. 1.

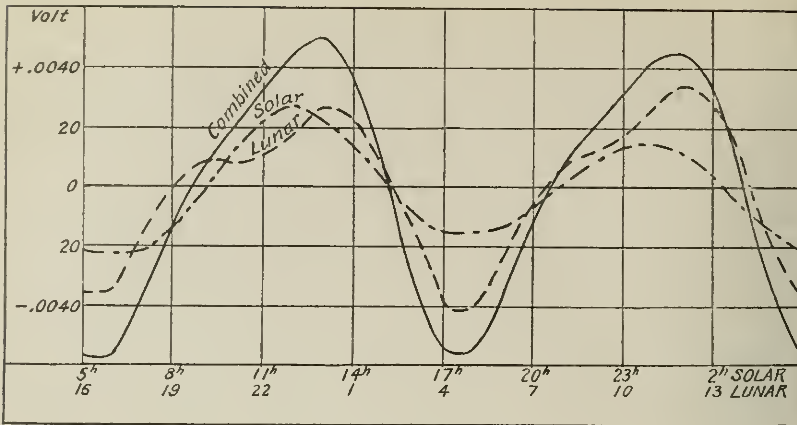

Fig. 2.

Table 2.—*Analysis of the electric tide at Jersey according to the 12 lunations from October 1917 to September 1918.*

[Tabular quantities are expressed in ten-thousandths of a volt.]

Hours		Tide			Hours	Moon	
Solar	Lunar	Combined	Solar	Lunar	Lunar	Apogee	Perigee
h	h				h		
5	16	−56	−21	−35	16	−38	−67
6	17	−56	−22	−34	17	−42	−71
7	18	−37	−21	−16	18	−33	−54
8	19	−13	−13	00	19	−08	−31
9	20	+07	−02	+09	20	+07	−04
10	21	+20	+12	+08	21	+12	+21
11	22	+33	+22	+11	22	+25	+40
Noon	23	+45	+27	+18	23	+33	+31
13	0	+50	+23	+27	24	+38	+51
14	1	+37	+14	+23	0	+35	+58
15	2	+06	+02	+04	1	+32	+39
16	3	−30	−08	−22	2	+02	−02
17	4	−54	−15	−39	3	−25	−61
18	5	−55	−15	−40	4	−42	−85
19	6	−36	−13	−23	5	−45	−81
20	7	−11	−06	−05	6	−40	−45
21	8	+08	+01	+07	7	−20	−12
22	9	+20	+09	+11	8	−05	+12
23	10	+31	+14	+17	9	+13	+36
Mid.	11	+42	+15	+27	10	+21	+51
1	12	+45	+11	+34	11	+23	+65
2	13	+33	+04	+29	12	+32	+76
3	14	+03	−06	+09	13	+29	+65
4	15	−33	−14	−19	14	+15	+34
					15	−15	−30
Mean voltage		977	....	....	....	983	979

The mean amplitudes of the double oscillation are as follows:

Combined tide, 0.0053 v; Solar tide, 0.0020 v; Lunar tide, 0.0035 v.

The relative importance of the three tides will be more exactly determined by the sums of all the hourly divergences from the mean voltages and again by the amplitudes of the sêmi-diurnal waves derived from the harmonic computation of the three series.

	Sums of differences			Amplitudes of the semi-diurnal waves		
Combined tide	7580		10	0.0049		10
Solar tide	3090	or	4	0.0020	or	4
Lunar tide	4648		6	0.0029		6

3. A final similarity of the two ocean and electric tides will show their close relations.

If for every day of the lunation (mean of 12 lunations) we compute the hour of the Moon's transit for the meridian of Jersey and if we establish the daily retardations of the minimum of the current and of the high water of the afternoon, they are found to be affected by the same rather interesting inequality. The retardations (lunitidal intervals) increase at the syzygies and diminish at the quadratures; on the average the electric minimum is registered 3 hours and 50 minutes after the transit of the Moon and the lagging of the high water is 6 hours and 1 minute. Table 3 gives the advances (+) or the retardations (−) with reference to these two mean times, which are observed during the entire course of the lunation.

TABLE 3.—*Semi-monthly inequalities in the retardations of the two tides with reference to the passage of the Moon at meridian.*

	Electric Minimum	High Water		Electric Minimum	High Water
	m	m		m	m
1st day	+20	+28	16th day	+19	+21
2nd "	+13	+40	17th "	+19	+20
3rd "	+07	+10	18th "	+19	+16
4th "	+02	−01	19th "	+05	+05
5th "	−11	−14	20th "	−16	−07
6th "	−25	−26	21st "	−31	−19
7th "	−26	−32	22nd "	−40	−30
8th "	−31	−40	23rd "	−43	−34
9th "	−37	−46	24th "	−38	−27
10th "	−32	....	25th "	−16	−02
11th "	....	−36	26th "	+16	+21
12th "	−12	−14	27th "	+47	+44
13th "	+10	+01	28th "	+58	+50
14th "	+20	+06	29th "	+52	+47
15th "	+22	+11	30th "	+32	+38

		h	m
Mean retardation	Electric minimum	3	50
	High water	6	01

I have proved, for the electric tide, that this inequality affects it entirely, in the two minima as well as in the two maxima of voltage.

Can there now be any plausible doubt regarding the relation of the two tides?

Concluding Remarks

In 1895 the French engineer, F. de Saintignon published a *new* theory of the tides which has to do not with the vertical component of the force of attraction of the heavenly bodies, but with its horizontal component only. It deduces therefrom the existence of a *differential force* which tends to and succeeds in separating in its direction the near-by liquid molecules and in creating finally a depression which would be the principal effect of the attraction. Whence the author concludes that the low tide is the true tide. It would be the true expression of the action of the attracting forces of the heavenly bodies; the high tide would exist only in order to make place for the displaced molecules of the low tide.

According to this manner of reasoning, it would be possible to explain better the relation which observation obliges us to make between the maximum of the electromotive force developed by the ocean tide and the maritime depression or low tide. I do not insist on this matter knowing well that the question of the origin of an electric tide derived from the ocean tide will not fail to attract attention and to call forth discussion which will finally lead to its solution.

[It is hoped that Father Deschevrens' results will stimulate others to institute similar observations elsewhere, in order to settle the question, which at first naturally arises, whether the Jersey results may not be purely local in their nature. If they are not local, it will be of interest to determine under what conditions the electric currents may be caused by the tidal motion of conducting masses of water across the vertical component of the Earth's magnetic field. That is to say, are there electric currents brought about in the Earth's crust by electro-magnetic induction as the result of the earth and ocean tides just as Schuster supposes electric currents produced in the regions above us by the motion of conducting air-masses across the vertical component of the Earth's magnetic field? If so, some of the Jersey results may be explained readily. —Ed.]

MAGNETIC OBSERVATIONS AT LUKIAPANG, CHINA, DURING LUNAR ECLIPSES, DECEMBER 28, 1917 AND JUNE 24, 1918.

BY J. DE MOIDREY, S. J.

The total eclipse of the Moon on December 28, 1917, was visible at Lukiapang. Fig. 1 reproduces the magnetograms for D and H; the Z-magnetogram turned out bad. Care was taken to have the magnetograph in good condition. Absolute determinations had been made for D on the 27th, and for H and I on the 28th. Determinations of sensitivity were made immediately afterwards and in fact a little too soon—before the emergence from the penumbra.

A millimeter equals for D, $0'.48$; for H, 1.47γ; for Z, 5.21γ.

As the mean values suffice in the present instance, we have:

Dec. 27, 1917	$D=3^\circ\ 16'.42$ W	at $9^h\ 25^m$	(China coast time, 120° east of Gr.)
	$=3^\circ\ 20'.87$	at 14 04	
Dec. 28, 1917	$H=33209\gamma$	at 10 07	
	$I=45^\circ\ 32'.33$	at 14 44	

We have marked with arrows the entrance into the penumbra and the emergence from it, the entrance into the umbra and the emergence therefrom, and the beginning and end of the totality.

In so short a period of time, the temperature-variation may be regarded as negligible. The temperature fell almost 0°.5 and the temperature coefficient is 38.57.

The hours marked in Fig. 1 are Greenwich time. The declination is west and the horizontal intensity increases towards the top. The original scale was drawn in centimeters; Fig. 1 is, however, a *half-size* reproduction.

Fig. 2 is a full-size reproduction of the magnetograms obtained during the eclipse of the Moon, not visible here, of June 24, 1918; the scale is in centimeters.

A millimeter equals for D, $0'.48$; for H, 1.47γ on June 25 at 11^h; for Z, 3.6γ on June 24 at 11^h and 4.4γ on June 25 at 11^h.

The mark is at $17^h\ 00^m$.

The absolute values at $17^h\ 27^m$, June 25, 1918 are:

$D=3^\circ\ 19'.1$W (3 measures in the morning)
$I=45^\circ\ 30'.86$ (obtained by the inductor at $17^h\ 27^m$)
$H=33194\gamma$ (2 measures at $14^h\ 45^m$ and $16^h\ 22^m$)

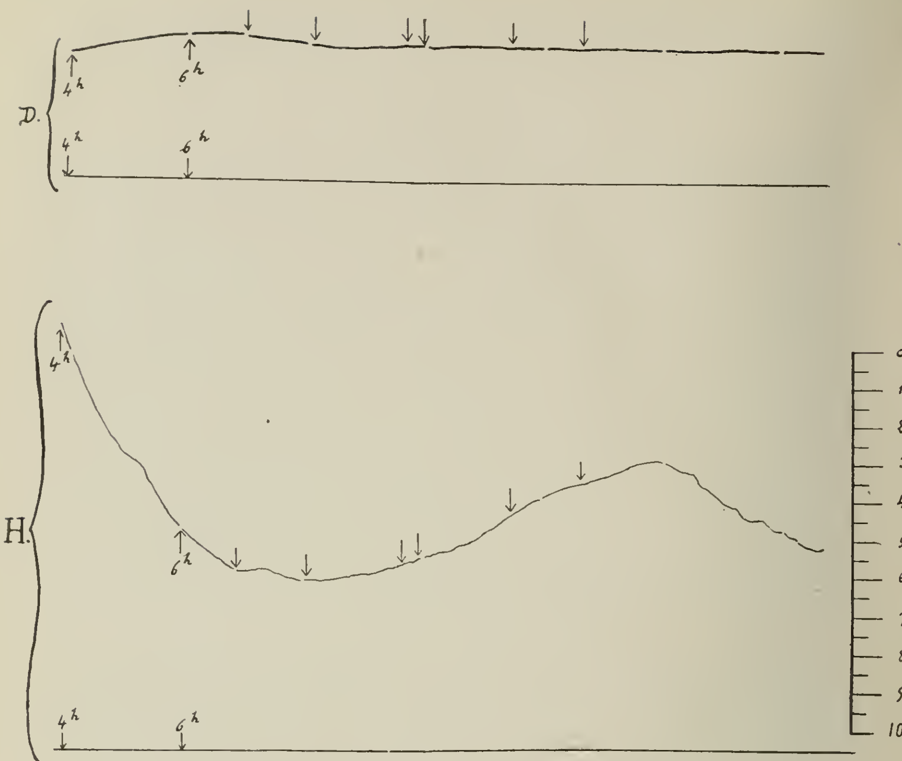

FIG. 1.—Lunar Eclipse of December 28, 1917.

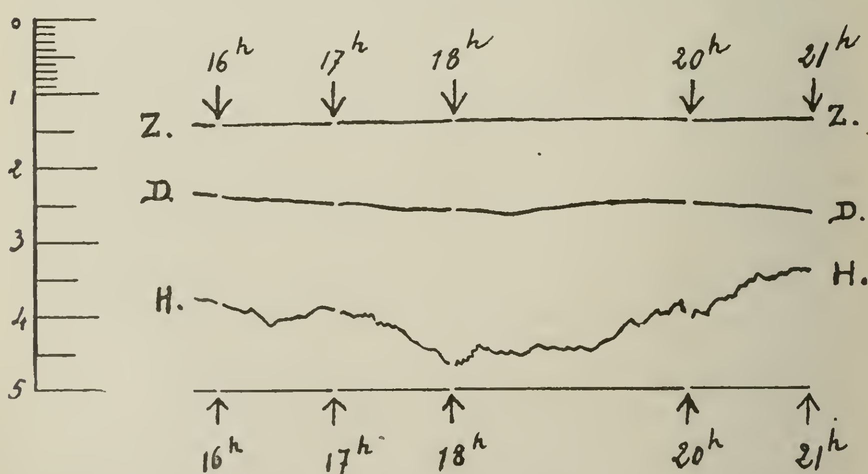

FIG. 2.—Lunar Eclipse of June 24, 1918.

PROPOSED MAGNETIC AND ALLIED OBSERVATIONS DURING THE TOTAL SOLAR ECLIPSE OF MAY 29, 1919.

By L. A. Bauer.

Special magnetic and allied observations will be made at certain stations inside and outside the shadow belt of the total solar eclipse of May 29, 1919, by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, and by various magnetic observatories, institutions and individuals who have offered their cooperation. The stations of the Department of Terrestrial Magnetism will be probably: 1. La Paz, Bolivia; 2. Huancayo (north of belt of totality); 3. Near Sobral, Brazil; 4. Île Principe or Libreville, French Congo; 5. Stations outside belt of totality by field parties as found possible. At station 3 complete magnetic and electric observations will be attempted.

The general scheme of work proposed by the Department of Terrestrial Magnetism is as follows:

1. *Simultaneous magnetic observations* of any or all of the elements according to the instruments at the observer's disposal, every minute from May 29, 1919, $9^{h}\,58^{m}$ A. M. to $4^{h}\,32^{m}$ P. M. Greenwich civil mean time, or from May 28, $21^{h}\,58^{m}$ to $4^{h}\,32^{m}$, May 29, Greenwich astronomical mean time.

(To insure the highest degree of accuracy, the observer should begin work early enough to have everything in complete readiness in proper time. *Past experience has shown it to be essential that the same observer make the readings throughout the entire interval.* If possible, similar observations for the same interval of time, as on May 29, should be made on May 28 and 30.)

2. At *magnetic observatories*, all necessary precautions should be taken to insure that the self-recording instruments will be in good operation not only during the proposed interval but also for some time before and after, and eye-readings should be taken in addition wherever it is possible and convenient. (*It is recommended that, in general, the magnetograph be run on the usual speed throughout the interval, and that, if a change in recording speed be made, every precaution possible be taken to guard against instrumental changes likely to affect the continuity of the base lines.*)

3. *Atmospheric-electric observations* should be made to the extent possible with the observer's equipment and personnel at his disposal. At least observations of potential-gradient and conductivity (preferably both positive and negative) should be made.

4. *Meteorological observations* in accordance with the observer's equipment should be made at convenient periods (as short as possible) throughout the interval. It is suggested that, at least, temperature be read every fifth minute (directly after the magnetic reading for that minute).

5. *Observers in the belt of totality* are requested to take the magnetic reading every thirty seconds during the interval, 10 minutes before and 10 minutes after the time of totality, and to read temperature also every 30 seconds, between the magnetic readings.

It is hoped that full reports will be forwarded as soon as possible for publication in the journal of *Terrestrial Magnetism and Atmospheric Electricity.* Those interested are referred to the results of the observations made during the solar eclipse of June 8, 1918, the publication of which was begun in the September 1918 issue of this journal. A summary of the magnetic results obtained is given in this issue, page 16.

General Circumstances of the Total Solar Eclipse of May 29, 1919.

	Greenwich Civil Mean Time			Longitude from Greenwich		Latitude	
	d	h	m	°	′	°	′
Eclipse begins May	29	10	33.5	63	27W	14	6 S
Central eclipse begins	29	11	30.1	75	9W	19	43 S
Central eclipse at local apparent noon	29	13	6.6	17	23W	4	18 N
Central eclipse ends	29	14	47.4	42	27 E	12	25 S
Eclipse ends	29	15	44.0	30	36 E	6	46 S

Approximate Local Circumstances of the Solar Eclipse of May 29, 1919.

Station	Latitude	Longitude	Greenwich Civil M. T. of Eclipse: Beginning	Middle	End	Loc. M. T. Middle	Magnitude	Duration of Totality
	° ′	h m	h m	h m	h m	h m		m s
Tacna, Chile	18 00.8 S	4 45W	11 07[1]	11 30.6	12 33	6 46	1.019	3 01
La Paz, Bolivia	16 30.8 S	4 33W	10 56[1]	11 31.0	12 35	6 58	1.019	3 07
Caxias, Brazil	4 59 S	2 51W	10 43	11 56.1	13 21	9 05	1.026	4 55
St. Paul's Rocks	0 55.5 N	1 58W	11 03	12 28.2	14 05	10 30	1.028	6 06
Libreville, French Congo	0 23 N	0 38 E	12 53	14 20.1	15 34	14 58	1.024	4 56
Bolobo	2 09 S	1 05 E	13 11	14 31.2	15 40	15 36	1.021	4 17
South of Mikindani	10 30 S	2 40 E	13 46	14 47.4	15 00[2]	17 27	0.999	....
Mikindani	10 16.5 S	2 41 E	13 46	14 47.5	15 00[2]	17 28	0.989	....

[1] Time of Sunrise (Geometric). Magnitude at Sunrise: Tacna, 0.616; La Paz, 0.417.

[2] Time of Sunset (Geometric). Magnitude at Sunset: Mikindani, 0.78; South of Mikindani, 0.78.

Referring to the Nautical Office map showing the belt of totality as reproduced on page 141 of the previous volume, attention should be called to the fact that the belt at its middle point does not extend far enough north; the central line should pass a few miles north of Cape Palmas, Liberia. Notes on the geographical and meteorological conditions at some favorable stations are published by A. R. Hinks in *The Observatory* for April, 1917 (pp. 153-157) and in the *Monthly Notices of the Royal Astronomical Society* for November 1917 (pp. 79-82).

DEPARTMENT OF TERRESTRIAL MAGNETISM,
CARNEGIE INSTITUTION OF WASHINGTON.

WOLFER PROVISIONAL SUN-SPOT NUMBERS FOR APRIL TO JUNE 1918.

COMMUNICATED BY G. VAN DIJK.[1]

Date	April	May	June	Date	April	May	June
1	...	...	164	17	...	50	..
2	84	116	151	18	47	35	14
3	97	109	173	19	..	31	33
4	117	129	151	20	..	32	47
5	93	115	122	21	..	30	46
6	106	118	121	22	55	47	49
7	94	94	76	23	43?	28	40
8	...	89	74	24	47	33	37
9	88	104	44	25	43	43	31
10	79	115	...	26	62	64	36
11	35	98	19	27	68	59	25
12	73	97	...	28	..	59	46
13	69	99	17	29	96	62	73
14	67	72	14	30	93	106	68
15	...	67	13	31		139	
16	...	54	...				
				Means	76.5	76.5	64.8

[1] Derived from the *Meteorologische Zeitschrift;* for previous table, see *Terr. Mag.* vol. 23, p. 136.

NOTES

1. *Concerning Magnetic Observatories.* Regarding the *Orcades Meteorological and Magnetic Observatory on Laurie Island* (see note 9, vol. 23, p. 142), Prof. F. H. Bigelow under the date Aug. 25, 1918 wrote: "Lutzöw-Holm, Berg and Hammaren are this year [1918] at the Orcades; Valentine goes next season. Stuxberg brought back a fine record and instrumental data for 1917. We had the entire year completely reduced in July 1918. The *Pilar* work is now up to date, July 1918, and is running very smoothly. We are organizing the *La Quiaca Magnetic Observatory* (see note 9, vol. 23, p. 142), altitude 3465 meters; it is hoped to have the station in operation soon. Finances are very low and progress is retarded." In his letter of Aug. 19, 1918, Prof. Bigelow states that when he took charge of the *Pilar* observatory the absolute house of adobe was found "magnetized throughout and added 20γ to H-base lines." He has since built a new house of wood.

Dr. H. M. W. Edmonds left Washington for Peru, February 1919, to take charge of the construction of the proposed *magnetic observatory of the Department of Terrestrial Magnetism in South America.* He hopes to make a temporary installation of recording instruments for special magnetic observations during the solar eclipse of May 29, 1919.

Mr. W. F. Wallis, in charge of the *magnetic observatory of the Department of Terrestrial Magnetism at Watheroo, Western Australia*, reports that the buildings will probably be completed in time to have the recording instruments in operation by January 1, 1919.

2. *Solar-Constant Values 1917 and 1918, and the New Solar Observatory at Calama, Chile.* Referring to the table of Sun-spot numbers (vol. 23, p. 136), *Dr. C. G. Abbot*, director of the Astrophysical Observatory of the Smithsonian Institution, writes under the date of Oct. 3, 1918: "The table is very interesting, especially in view of the relatively very high solar-constant values secured by Messrs. Moore and L. H. Abbot in North Carolina and Chile in 1917 and 1918. Mt. Wilson results are not yet available. Messrs. A. F. Moore and L. H. Abbot have been at our new solar observatory at *Calama*, Chile, since June 1918 and began solar-constant observing July 27. They reported of the first 22 days 18 complete observations, and 15 already reduced, yielding all 'very good' or 'excellent' values ranging from 1.90 to 1.98, but averaging 1.96."

On Feb. 6, 1919, Dr. Abbot adds: "The work in Chile is progressing well. Solar-constant observations have been obtained on about 80 per cent of the days from July 27 to December 15. Dr. Clayton is testing the value of the results for forecasting weather conditions in Argentina. A daily telegraphic service between Calama and Buenos Aires has been arranged by him, and our observers are able generally to supply the solar-constant value on the same day obtained."

3. *Principal Magnetic Storms at Cheltenham Magnetic Observatory, July to December, 1918.*[1]

[1] Communicated by *R. L. Faris*, Acting Superintendent, U. S. Coast and Geodetic Survey; *Geo. Hartnell*, Observer-in-charge. Latitude, 38° 44.0′ N; Longitude, 76° 50.5′ W, or 5h 07.4m. W of Greenwich.

Greenwich Mean Time		Range		
Beginning	Ending	Declination	Hor'l Int.	Vert'l Int.
h m	h	′	γ	γ
Aug. 15, 15 50	Aug. 16, 14 ..	39.4	286	221
Sept. 21, 5 ..	Sept. 21, 23 ..	33.7	187	284
Oct. 16, 4 10	Oct. 17, 00 ..	49.4	236	261
Dec. 7, 22 ..	Dec. 10, 10 ..	39.1	144	160
Dec. 25, 13 30	Dec. 26, 1 ..	42.9	204	138

4. *Magnetic Observations during Amundsen's Arctic Expedition.* Complete magnetic observations were received by the Department of Terrestrial Magnetism the latter part of December 1918, through the Norwegian consul at Archangel and the United States Department of State at Washington, at the following stations of the Amundsen Arctic Expedition: Vaigach (Lat. 69°.7 N; Long. 60°.2 E) Aug. 12-13, 1918; Khabarowa (Lat. 69°.6 N; Long. 60°.4 E) on Aug. 15, 1918; Port Dixon (Lat. 73°.5 N; approx. Long. 81° E) on Sept. 2-3, 1918. Khabarowa is one of the magnetic stations established by the Nansen Polar Expedition in 1893. The magnetic instruments used by the Amundsen Arctic Expedition are those supplied by the Department of Terrestrial Magnetism, which also furnished the instructions and program of work. The results of the observations received thus far are very satisfactory.

5. *Personalia.* We regret to record the death of the well-known founder of the Ógyalla Meteorological and Magnetic Observatory, Dr. *N. Thege von Konkoly*, Feb. 17, 1916, at the age of 74. He founded the Observatory in 1871 and from 1890-1911 he was director of the Hungarian Institute for Meteorology and Terrestrial Magnetism in Budapest.

The French Academy of Sciences has awarded the Poncelet prize for the mathematical sciences this year to Sir *Jospeh Larmor.* Prof. *J. T. Morrison* was the presiding officer of section A (astronomy, mathematics, physics, meteorology, geodesy, surveying, engineering, architecture, and irrigation) of the South African Association for the Advancement of Science, held in Johannesburg, on July 8-13, 1918. Dr. *Horace Lamb*, professor of mathematics at the University of Manchester, will be the Halley lecturer at Oxford University in 1919.

Roald Amundsen of Christiania, and *G. Lecointe* of Brussels were elected in 1918 corresponding members of the French Academy of Sciences in the section of geography and navigation.

Dr. *Sidney Chapman* has been appointed for the summer of 1919 Research Associate in the Department of Terrestrial Magnetism. Capt. *E. Kidson* and and Cadet *Frederick Brown* will reënter the employ of the Department of Terrestrial Magnetism upon completion of their military duties.

Dr. *L. A. Bauer* left Washington early in March for England where he will organize an expedition for magnetic and electric observations during the solar eclipse of May 29, 1919 at a station in South Africa; he expects next to proceed to South America and arrange for similar observations during the eclipse there. While in South America he will visit various institutions and return to Washington next July.

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Terrestrial Magnetism
and
Atmospheric Electricity

VOLUME XXIV JUNE, 1919 NUMBER 2

THE VERTICAL-INTENSITY VARIOMETER.

By GEORGE HARTNELL.

For the purpose of recording the variations of the three magnetic elements, declination (D), horizontal intensity (H), and vertical intensity (Z), magnetic observatories use three instruments collectively called a magnetograph. One instrument called the D-variometer or sometimes the unifilar variometer records variations in declination; its magnet is suspended horizontally with north end of the magnet north in the magnetic meridian, by a single fibre of silk or quartz. Another, with north end of the magnet either east or west, is suspended in a horizontal plane by either a single fibre of quartz, or by a bifilar suspension of silk fibres; it records variation of the horizontal intensity and is called the H-variometer. In the case of the bifilar suspension it is sometimes called the bifilar variometer. The third instrument of the magnetograph, the Z- or vertical-intensity variometer, records variations in the vertical intensity. It consists essentially of a magnet supported on a horizontal axis, with freedom to move in a vertical plane. In construction the support may be an agate knife-edge resting on a horizontal plane of polished agate, or a pair of steel points resting on an agate plane or in shallow agate cups. In still another type, the magnet is attached to a quartz plate to which horizontal suspension fibres of quartz are fused. We shall discuss some of the characteristic features of the Z-variometer in which the magnet is supported by an agate knife-edge or by a pair of steel points resting on a horizontal plane, either form of support being called a knife-edge for brevity.

Referring to Fig. 1 let x and z be the coordinates of the center of gravity of the magnet system, x being positive toward the magnetic north, and z being positive vertically upward. The coordinate y, positive toward the east, is 0. The origin of co-

ordinates is at O, where the knife-edge touches the plane. Let h be the distance OO' perpendicular to the axis of the magnet; c, parallel to the axis of the magnet, the distance from O' to the center of gravity. θ is the angle which the magnet makes with the horizontal and is positive when the north end dips downward. Also let m be the mass of the magnet; M, the magnetic moment; H and Z, horizontal and vertical intensities; g, the acceleration of gravity; and k the radius of gyration around the center of gravity. Referred to this set of rectangular axes, H is positive while Z and g are negative; the force in the y direction is 0, when the magnet moves in a vertical plane in the magnetic meridian. In the actual construction of the variometer, the magnet is provided with two poises or small weights. One moves along h and alters the sensitivity by raising or lowering the center of gravity, and is here called the "sensitivity poise"; the other moves along c and is called the "balancing poise."

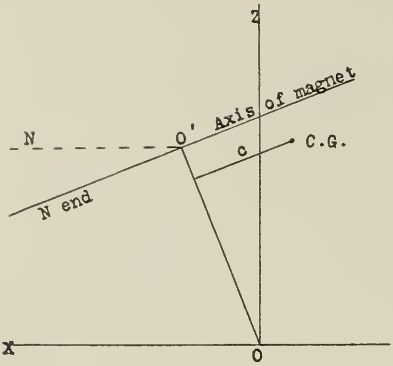

FIG. 1.

To determine the equation of motion we shall use Lagrange's equation:

$$\frac{d}{dt}\frac{dL}{d\dot{\xi}} - \frac{dL}{d\xi} = 0 \tag{1}$$

where L, the kinetic potential, is $T-V$, T being the kinetic energy and V the potential energy, and ξ is any coordinate desired.

In our problem the kinetic energy is

$$T = \frac{m}{2}\left(\dot{x}^2 + \dot{z}^2 + k^2\dot{\theta}^2\right) \text{ and } V = mgz - M(H\cos\theta + Z\sin\theta)$$

The coordinates of the center of gravity are

$$x = h\sin\theta - c\cos\theta, \text{ and } z = h\cos\theta + c\sin\theta$$

Substituting in T and V and reducing

$$T = \frac{m}{2}\left(h^2 + c^2 + k^2\right)\dot{\theta}^2 \text{ and } V = mg(h\cos\theta + c\sin\theta) -$$
$$M(H\cos\theta + Z\sin\theta)$$

Whence

$$L = T - V = \frac{m}{2}\left(h^2 + c^2 + k^2\right)\dot{\theta}^2 - m\,g\,(h\cos\theta + c\sin\theta) - M\,(H\cos\theta + Z\sin\theta)$$

Using this value of L in (1), θ being the coordinate desired, we get the equation of motion:

$$K_v\,\ddot{\theta} + (MH - mgh)\sin\theta + (mgc - MZ)\cos\theta = 0 \qquad (2)$$

where $K_v = m\,(h^2 + c^2 + k^2)$.

Equation (2) describes the action of two groups of impressed forces—namely, the magnetic forces and the gravity forces—on the motion of the magnet system. Among other ways, it could have been derived from considering how the two groups of forces are, so to speak, paired off against each other. Under ordinary operating conditions the magnetic turning-moment $M\,H\sin\theta$ is considerably larger than the gravity turning-moment $m\,g\,h\sin\theta$, and the resultant is a restoring force tending to keep the magnet level. The tendency of the magnetic turning-moment $M\,Z\cos\theta$ to upset the magnet is almost completely counterbalanced by the gravity turning-moment $m\,g\,c\cos\theta$. The resultant of all the turning-moments, when not zero, imparts motion to the magnet system and $= K_v\,\ddot{\theta}$.

Moreover, equation (2) represents an oscillation around a position of equilibrium. To determine this position, place $\ddot{\theta}$ in (2) = 0, and the condition to be fulfilled for equilibrium is

$$\tan\theta_0 = \frac{MZ - mgc}{MH - mgh} \qquad (3)$$

Or in case the instrument is not in the magnetic meridian as we have assumed

$$\tan\theta = \frac{MZ - mgc}{MH\cos A - mgh} \qquad (4)$$

where A is the azimuth of the vertical plane containing the magnet. The magnet will be level or balanced, that is θ will be 0, when $M\,Z - m\,g\,c = 0$ and this will be true for all azimuths or for all values of A. However, if $(M\,Z - m\,g\,c)$ is not exactly 0, as would probably be the case, θ would change as A changes.

If $c = h = 0$, that is, if the magnet were supported at its center of gravity, as would be true in the case of a perfectly symmetrical dip needle provided with conical pivots resting in agate cups such as is used at sea for determining the dip, I,

$$\tan \theta = \frac{Z}{H \cos A} \tag{5}$$

When $A=0$, $\tan \theta = \frac{Z}{H} = \tan I$; when $A=90°$, $\tan \theta = \infty$, and $\theta = 90°$, the north end of the magnet pointing vertically downward.

If the variometer is oriented in the magnetic prime-vertical,

$$A = 90°, \text{ and } \tan \theta = \frac{MZ - mgc}{-mgh}$$

In this position, the magnet will be unstable unless the "sensitivity poise" is lowered until the center of gravity is below the point of support, that is, below the surface of the agate plane. If $M=0$, that is if the magnet were merely a non-magnetic body, it would become simply a compound pendulum.

In order to determine the periods of the magnet for different azimuths, let the magnet be displaced from the position of equilibrium θ_0 by a small angle $d\,\theta$, so that θ becomes $\theta_0 + d\,\theta$. Substituting in (2) and introducing A and rearranging we get

$$K_v \ddot{\theta} + \Big[(MH \cos A - mgh) \cos \theta_0 - (mgc - MZ) \sin \theta_0 \Big] \sin d\theta$$
$$+ \Big[(MH \cos A - mgh) \sin \theta_0 + (mgc - MZ) \cos \theta_0 \Big] \cos d\theta = 0 \tag{6}$$

The period, that is, the time required to describe half a complete vibration will be

$$T^2_v = \frac{\pi^2 K_v}{(MH \cos A - mgh) \cos \theta_0 - (mgc - MZ) \sin \theta_0} \tag{7}$$

When the magnet is level, $m\,g\,c - M\,Z = 0$, $\theta_0 = 0$ and the period is

$$T^2_v = \frac{\pi^2 K_v}{MH \cos A - mgh} \tag{8}$$

If the magnet also lies in the magnetic meridian, $A=0$, and the period is

$$T^2_v = \frac{\pi^2 K_v}{MH - mgh} \tag{9}$$

And if h is 0,

$$T^2_v = \frac{\pi^2 K_v}{MH}$$

If $A = 90°$ and $\theta_0 = 0$, $T^2_v = \frac{\pi^2 K_v}{-mgh}$, the magnet would be unstable unless the "sensitivity poise" were lowered until the center of gravity were below the point of support and h made

negative. It will be seen that H does not appear in this equation; in other words the horizontal intensity, being perpendicular to the plane in which the magnet moves, has no effect on its motion and thus no effect on its period and sensitivity.

When $h = c = 0$,

$$T^2_v = \frac{\pi^2 K_v}{MH \cos A \cos \theta_0 + MZ \sin \theta_0} \tag{10}$$

If $A = 0$,

$$T^2_v = \frac{\pi^2 K_v}{MH \cos \theta_0 + MZ \sin \theta_0} = \frac{\pi^2 K_v}{MH \cos I + MZ \sin I}$$

$$= \frac{\pi^2 K_v \sin I}{MZ} = \frac{\pi^2 K_v \cos I}{MH} = \frac{\pi^2 K_v}{MF} \tag{11}$$

where $F = \sqrt{H^2 + Z^2}$ = the total magnetic intensity. For $A = 90°$, and so $\theta_0 = 90°$,

$$T^2_z = \frac{\pi^2 K_v}{MZ} \tag{12}$$

Moreover,

$$\frac{MZ}{MF} = \sin I = \frac{\pi^2 K}{T^2_z} \div \frac{\pi^2 K}{T^2_F} = \frac{T^2_F}{T^2_z} \tag{13}$$

From equation (13) the dip I could be obtained by determining the periods of the magnet when oscillating in and perpendicular to the magnetic meridian. Equations (10), (11), (12), and (13) are simply illustrations of the law that the square of the period of a vibrating body varies inversely as the force. In all the foregoing expressions for T and θ, the denominators must be positive, otherwise the periods will be imaginary, and the magnet will not be stable and will not oscillate.

Returning to equation (3) which specifies the position of equilibrium of the magnet when in the magnetic meridian, that position will be when the magnet is level if

$$MZ = mgc \tag{14}$$

To get a concrete idea of the magnitude of c at a station where $Z = 0.554$ and $g = 981$, let us take a magnet which we shall call magnet J, having mass 61.0 and the magnetic moment 750.0, all quantities being expressed in C.G.S. units. With these values c will be 0.0069 cm. = 0.069 mm. = 69μ.

Differentiating equation (3) with reference to θ and Z, θ being a small angle, and solving

$$dZ = \frac{MH - mgh}{M}\, d\theta$$

Let ϵ be the scale value, and n the number of divisions through which the magnet is deflected, and θ_r the value in radian of one millimeter on the magnetogram.

Then

$$dZ = n\epsilon = \left(\frac{MH - mgh}{M}\right) n\,\theta_r$$

and

$$\epsilon = \left(\frac{MH - mgh}{M}\right) \theta_r \tag{15}$$

For a concrete idea of h, let us compute h from (15) for the usual scale-value of 5γ per mm. on the magnetogram, H being taken as 0.192. For example, if the magnet J were mounted as a Z-variometer at the distance $R=150$ cm. from the drum of the recording apparatus, h would be 0.00053 cm.$=$0.0053 mm.$=5\mu$ approximately. If it were mounted at the distance $R=230$ cm. h would be -0.00047 cm.$=-0.0047$ mm.$=-5\mu$ approximately. It will thus be seen that both h and c are exceedingly small quantities. For $R=150$ cm., h is positive, and the center of gravity is slightly above the knife-edge; for $R=230$ cm., h is negative, and the center of gravity is slightly below the knife-edge. If desired, we could compute from (15) the distance at which to place the variometer for a given scale-value when $h=0$; thus $R=\frac{H}{20\epsilon}$ since $\theta_r=\frac{1}{20R}$. For any azimuth the scale-value would be $\epsilon = \frac{MH\cos A - mgh}{M}$, and for a Z-variometer oriented in the magnetic prime-vertical $\epsilon=\frac{-mgh}{M}\theta_r$, the center of gravity being slightly below the knife-edge. Under these circumstances and for a distance of $R=230$ cm., $h=-0.0029$ cm.$=-0.029$ mm.$=-29\mu$.

If h were 0, (15) would become

$$\epsilon = H\theta_r \tag{16}$$

from which it follows that since MH is considerably larger than mgh, the chief factors determining the scale-value of a variometer in the magnetic meridian are the horizontal intensity and the distance.

At a station where there is a secular decrease in H, the scale-value would be expected to decrease, that is the variometer would become more sensitive in the course of time. However, it will be shown later that a rolling magnet is less sensitive than a pivoting magnet; and from (15) it is clear that a decrease in h will also decrease the sensitivity. So if the variometer loses sensi-

tivity, the probable explanation is that the loss of sensitivity due to the wearing away and rounding off of the knife-edge more than offsets the increase of sensitivity due to the secular decrease in H. These remarks may be made sufficiently clear by considering the pivoting magnet only. For a small change $d\epsilon$ in scale-value we have $d\epsilon = \frac{M\,dH - m\,g\,dh.}{M}$ If the scale-value is constant, dH being negative, $-dh = \frac{M\,dH}{m\,g}$. Since $\frac{M}{m\,g}$ is a small fraction, the decrease in the length h is sufficient to offset the decrease in scale-value due to decrease in H, is only a small fraction of the decrease in H. Hence while the distance and the horizontal intensity largely determine the actual scale-value, changes in the length h may, under some circumstances, be the controlling factor in causing scale-value changes.

In actual construction the knife-edge is equidistant from the geometrical center of the magnet, and the center of gravity of the magnet system is below the knife-edge or plane and the magnet is balanced and adjusted to the desired sensitivity by moving the poises. Let m' be the mass of the "sensitivity poise," h' its distance from the supporting plane measured perpendicular to the axis of the magnet; and let l be the distance of the center of gravity below the plane. Also let m'' be the mass of the balancing poise, and c'' its distance from the geometrical center of the magnet, measured along the axis. Then in the above equations

$$h = \frac{m'\,h' - m\,l}{m} \text{ and } c = \frac{m''\,c''}{m} \tag{17}$$

where m equals the combined mass of magnet and poises.

If the magnet were suspended with knife-edge vertical and oscillated in a horizontal plane, the period would be

$$T^2{}_h = \frac{\pi^2\,m\,k^2}{M\,H} \tag{18}$$

Using the equations (9) and (18) we have from (15)

$$\epsilon = \frac{H\,T^2{}_h}{T^2{}_v}\left(\frac{h^2 + c^2 + k^2}{k^2}\right)\theta_r$$

or since h and c are small compared with k

$$\epsilon = \frac{H\,T^2{}_h\,\theta_r}{T^2{}_v} \tag{19}$$

Usually the scale-value is determined by deflecting at equal distances in the same relative positions both the D-variometer and the Z-variometer by an auxiliary magnet. Thus

$$\epsilon = \frac{H \tan u}{n} \tag{20}$$

u being the angular deflection of the D-variometer. Equation (19) provides a method of determining ϵ by oscillations of the magnet in vertical and horizontal planes and is useful as a check on (20). As recording Z-magnets are surrounded by massive copper dampers, the oscillations in a vertical plane will require a correction for damping.

At the risk of digressing somewhat from the main subject, we may make the above equations for the periods and positions of equilibrium still more general and derive from them some interesting results. The equation of equilibrium (3) may be written

$$\tan \theta_0 = \frac{M F_z - G_z c}{M F_x - G_z h} \tag{21}$$

in which F_x, F_y, F_z are the magnetic forces, and G_x, G_y, and G_z are the gravity forces along the coordinate axes. For any other set of rectangular axes equation (21) may be written

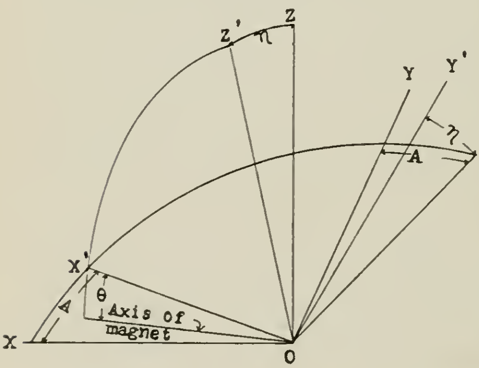

FIG. 2.

$$\tan \theta_0 = \frac{M F_{z'} - G_{z'} c}{M F_{x'} - G_{z'} h} \tag{22}$$

in which $F_{x'}$, $F_{y'}$, and $F_{z'}$ are the magnetic forces and $G_{x'}$, $G_{y'}$, and $G_{z'}$ are the gravity forces along the new axes, M, h, and c being the same as in the old axes. The two sets of axes are shown in Fig. 2.

The direction cosines between the axes are given in the following scheme:

	X	Y	Z
X'	$\cos A$	$\sin A$	0
Y'	$-\sin A \cos \eta$	$\cos A \cos \eta$	$\sin \eta$
Z'	$\sin A \sin \eta$	$-\cos A \sin \eta$	$\cos \eta$

We have $F_{x'} = F_x \cos(XX') + F_y \cos(YX') + F_z \cos(ZZ')$, and similar formulae for the remaining new axes. For the gravity forces, $G_{x'} = G_x \cos(XX') + G_y \cos(YX') + G_z \cos(ZX')$ and similar formulae for the other two new axes. Since $F_x = H$, $F_y = 0$, $-F_z = -Z$, $G_x = 0$, $G_y = 0$, and $-G_z = -m\,g$, we have

$$\left.\begin{array}{ll} F_{x'} = H \cos A & G_{x'} = 0 \\ F_{y'} = -H \sin A \cos \eta - Z \sin \eta & G_{y'} = m\,g \sin \eta \\ -F_{z'} = -H \sin A \sin \eta + Z \cos \eta & -G_{z'} = -m\,g \cos \eta \end{array}\right\} \qquad (23)$$

Substituting (23) in (22) noting that the forces $F_{y'}$ and $G_{y'}$ being perpendicular to the direction of motion, do not affect the motion of the magnet, we have

$$\tan \theta_0 = \frac{M(Z \cos \eta - H \sin A \sin \eta) - m\,g\,c \cos \eta}{M\,H \cos A - m\,g\,h \cos \eta} \qquad (24)$$

For $\eta = 0$, (24) becomes equation (4) which has already been discussed. For $\eta = 90°$, $\tan \theta_0 = \dfrac{-M\,H \sin A}{M\,H \cos A} = -\tan A$, and $(\theta_0 + A) = 0$. The magnet will be level and in the magnetic meridian, being sustained in a horizontal plane by the reactions at the knife-edge which is supposed to be replaced by suitable bearings. Suspending the magnet by a fibre at the point O' such that the center of gravity and the point O' are in the same vertical plane, h will be 0 and we shall have the ordinary unifilar suspension. For $M = 0$, we have the inclined compound pendulum and $\tan \theta_0 = \dfrac{c}{h}$ (unstable position for positive value of h and stable position for negative value of h); the center of gravity lies in the plane $Z\,O\,Z'$ and the line h makes the angle $\tan^{-1} \dfrac{c}{h}$ with $O\,Z'$. If $c = 0$, $\theta_0 = 0$ and h lies in the plane $Z\,O\,Z'$. For $M = 0$ and $\eta = 0$, $\tan \theta = \dfrac{c}{h}$; and for $c = 0$, $\theta_0 = 0$ and h is vertical downward and we have the ordinary compound pendulum. For $M = 0$ and the angle $ZZ' = 90° + \eta$, η being a small angle, $\tan \theta_0 = \dfrac{c}{h}$ and if $c = 0$, $\theta_0 = 0$, h lies in the plane $Z\,O\,Z'$, and we have the horizontal pendulum. For $A = c = h = 0$,

$$\tan \theta_0 = \frac{Z}{H} \cos \eta \qquad (25)$$

If $\eta = 90°$ the magnet would be horizontal and in the magnetic meridian. For $A = 0$

$$\tan \theta_0 = \frac{(MZ - mgc) \cos \eta}{MH - mgh \cos \eta} \tag{26}$$

According to equations (25) and (26) an error in θ_0 due to an error in level, would depend on cos η, η being taken perpendicular to the magnetic meridian, and would be small or negligible if η is small. According to equation (4) a displacement in θ_0 due to an accidental displacement in A by jarring the instrument would likewise be small for small displacements; and moreover according to equation (15) a change in scale-value due to the same cause would be small or negligible.

The general expression for the period of the magnet when it lies in the magnetic meridian, and is thus referred to the axes shown in Fig. 1, may be obtained from equation (7) by placing $A = 0$. Thus

$$T^2_a = \frac{\pi^2 K_v}{(MH - mgh) \cos \theta_0 - (mgc - MZ) \sin \theta_0} \tag{27}$$

Referred to the new axes shown in Fig. 2 equation (27) may be written

$$T^2_v = \frac{\pi^2 K_v}{(M F_{x'} - G_{z'} h) \cos \theta_0 - (G_{z'} c - M F_{z'}) \sin \theta_0}$$

Substituting from (23), the period referred to the new axes is

$$T^2_t = \frac{\pi^2 K_v}{(MH \cos A - mgh \cos \eta) \cos \theta_0 - [\, mgc \cos \eta - M (Z \cos \eta - H \sin A \sin \eta) \,] \sin}$$

For $\eta = 0$, (28) reduces to equation (7). For $\eta = 90°$ and hence $\theta_0 = A = 0$, as shown above, (28) reduces to (18); the magnet is level and moves in a horizontal plane; if it is suspended at the point O' by a fibre, $h = 0$ and we have the ordinary unifilar suspension. For $M = c = 0$, and so $\theta_0 = 0$, as shown above, we have an inclined compound pendulum oscillating around a fixed axis; its period is

$$T^2 = \frac{\pi^2 K_v}{m\,g\,h \cos \eta}$$

For $M = \eta = c = \theta_0 = 0$, we have the ordinary compound pendulum oscillating around a fixed horizontal axis. For $M = c = 0$ and $ZZ' = 90° + \eta$, η being small, we have the period of the horizontal pendulum

$$T^2_v = \frac{\pi^2 K_v}{m\, g\, h\, \eta} \tag{29}$$

For $A = c = h = 0$

$$T^2_v = \frac{\pi^2 K_v}{M\, H \cos \theta_0 + M\, Z \cos \eta \sin \theta_0}$$

which shows the effect of error in level. For $\eta = 0$, this equation becomes (11) and for $\eta = 90°$, and so $\theta_0 = 0$, it becomes (18). For $A = 0$, $(m\, g\, c - M\, Z) \doteq 0$ and so $\theta_0 = 0$

$$T^2_v = \frac{\pi^2 K_v}{M\, H - m\, g\, h \cos \eta}$$

which shows the error in period of the vertical-intensity variometer due to error in level. If $\eta = 0$, this equation becomes (9).

We shall next take up the case where the magnet rolls on an axle of sensible diameter, $2r$, for example the ordinary dip needle, and thus does not pivot or rotate around a fixed axis, as we have so far assumed. Since we are interested chiefly in the small oscillations, we may refer the center of gravity to the moving origin P (Fig. 3). The coordinates of the center of gravity are $x = (a \sin \dot{\phi} - c \cos \phi)$ and $z = (r + a \cos \phi + c \sin \phi)$ hence $\dot{x}^2 + \dot{z}^2 = (a^2 + c^2)\, \dot{\phi}^2$. The equation of motion from (1) is

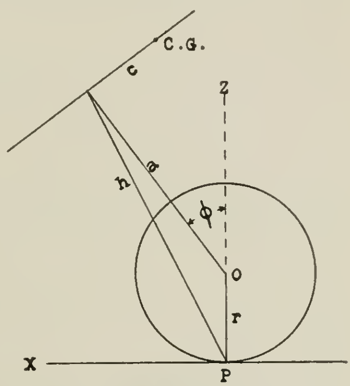

Fig. 3.

$$\frac{d}{dt}\frac{dL}{d\dot{\phi}} - \frac{dL}{d\phi} = 0$$

L, the kinetic potential, is equal to T, the kinetic energy, minus V, the potential energy. As before $T = \frac{m}{2}(\dot{x}^2 + \dot{z}^2 + k^2 \dot{\phi}^2) = \frac{m}{2}(a^2 + c^2 + k^2)\, \dot{\phi}^2$ and $V = mg\,(r + a \cos \phi + c \sin \phi) - M\,(H \cos \phi + Z \sin \phi)$. Then from the equation of motion and after differentiation substituting $\sin \phi = \phi$ and $\cos \phi = 1$, since ϕ is small, we have $m\,(a^2 + c^2 + k^2)\, \phi - (mga - MH)\, \phi + mgc - MZ = 0$. For the case when the magnet is level, since then $MZ = mgc$ and substituting the approximate value of $K_v\, \ddot{\phi}$ for the first term, we have

$$K_v \ddot{\phi} + (M\,H - m\,g\,a)\,\phi = 0 \tag{30}$$

The relation between a and h is $h^2 = a^2 + r^2 + 2ar \cos\,\phi$ and when ϕ is small

$$a = h - r \tag{31}$$

Eliminating a by means of (31), (30) becomes

$$K_v\,\phi + (M\,H - m\,g\,h + m\,g\,r)\phi = 0$$

and for rolling

$$T^2_v + \frac{\pi^2\,K_v}{M\,H - m\,g\,h + m\,g\,r}$$

The work done in deflecting the pivoting magnet through a small angle θ is $\int (MH - mgh)\,\theta\,d\theta = \frac{1}{2}(MH - mgh)\,\theta^2$; and the work done in deflecting the rolling magnet is $\int (MH - mgh + mgr)\;\phi\;d\,\phi = \frac{1}{2}(MH - mgh + mgr)\;\phi^2$. When the magnet is deflected by another magnet as in scale-value deflections, the work done on it is the same whether it rolls or pivots. Hence

$$(M\,H - m\,g\,h)\;\theta^2 = (M\,H - m\,g\,h + m\,g\,r)\;\phi^2 \tag{32}$$

As the expression in the parenthesis on the left is smaller than the parenthesis on the right, θ is greater than ϕ, or a pivoting magnet is more sensitive than a rolling magnet. The same conclusion would be reached by comparing the potential energies and the periods of the rolling and pivoting magnets. Writing (32) in the form

$$\frac{M\,H - m\,g\,h + m\,g\,r}{M\,H - m\,g\,h} = \frac{\theta^2}{\phi^2} \quad \text{or} \quad \frac{m\,g\,r}{M\,H - m\,g\,h} = \frac{\theta^2 - \phi^2}{\phi^2} \quad \text{and}$$

$$r = \left(\frac{M\,H - m\,g\,h}{m\,g}\right)\left(\frac{\theta^2 - \phi^2}{\phi^2}\right) = \left(\frac{M\,\epsilon}{m\,g\,\theta_r}\right)\frac{\theta^2 - \phi^2}{\phi^2} \tag{33}$$

from which r may be computed. For example, if magnet J were adjusted to a scale-value of 5γ per mm. on the magnetogram at the distance $R = 230$ cm. from the drum and showed the unequal deflections, $\phi = 35$ mm. and $\theta = 37$ mm. the angles being proportional to the deflections in mm., r would be 0.0003 cm. = 0.003 mm. = 3μ if we assume that the magnet rolls in one direction and pivots in the other. If r is not the same in both directions, there will be two different periods and likewise two different scale-values, according to the direction of the deflections.

There are causes of unequal deflections other than the unequal curvatures in the knife-edge, for example a magnet rolling on a

plane inclined at a small angle. The discussion of this question would require the investigation of the potential energy function V in the neighborhood of a minimum, and need not be considered here. For the motion of a body around a position of equilibrium is, in general, symmetrical up to the second powers of the displacements if they are small, and the motion of the magnet of a Z-variometer is of that type.

To obtain the equation of equilibrium of the rolling magnet, place $\frac{dV}{d\phi}=0$, V being the complete form of the potential energy as given above. If the magnet is not in the magnetic meridian, we shall get

$$\tan\phi = \frac{M\,Z - m\,g\,c}{M\,H\cos A - m\,g\,a}$$

For the ordinary dip needle having an axle or pivots of sensible diameter the center of gravity coincides with the center of the pivots and $a=h-r=c=0$, whence

$$\tan\phi = \frac{\tan I}{\cos A}$$

which is the same as the equation (5) for the dip needle having pointed pivots.

It is a well-known phenomenon that magnets gradually lose their strength. Also the magnetic elements D, H, Z undergo small changes from year to year called secular changes. Returning to equation (3)

$$\theta_0 = \frac{M\,Z - m\,g\,c}{M\,H - m\,g\,h}$$

θ_0 would be expected to change gradually on account of changes in M, Z, and H. Regarding Z as constant for the present, let us decide whether changes in M or changes in H are more important in affecting θ. Dropping the relatively small term $m\,g\,h$ in the denominator, (3) may be written $M\,H\,\theta = M\,Z - m\,g\,c$. Differentiating with reference to M, H, and θ and solving for $d\theta$

$$d\theta = \left(\frac{Z}{H} - \theta\right)\frac{dM}{M} - \frac{\theta\,dH}{H}$$

The last term on the right is very small, and hence the important agent in causing a change in θ is the gradual loss of magnetism of the magnet. This change in θ will appear in the gradual change or drift in the base-line values. Writing $M=M_0(1-\alpha t)$, where α is the coefficient of magnetic loss per annum, and noting that at $t_0=0$, $\theta_0=0$, $Z\,M-m\,g\,c=0$

$$\triangle_1\theta = \frac{-\,Z\,M_0\,\alpha\,t}{H\,M_0\,(1-\alpha t) - m\,g\,h} \tag{34}$$

Using (15) and considering that $\triangle M = -M\alpha t$, we have

$$\frac{\epsilon\,(\triangle_1\theta)}{Z\,\theta_r} = \frac{\triangle Z}{Z} = \frac{\triangle M}{M} \tag{35}$$

or the apparent proportional change in Z (the drift in base-line value) equals the proportional loss of magnetism in the magnet. For magnet J mounted as a variometer and $\alpha = 0.001$ and $\epsilon = 5\gamma$, the base-line drift would be 55γ per annum, Z being 0.554.

It may be noted in passing that if α be taken as the temperature coefficient (34) and (35) also hold for temperature changes.

To take the effect of changes in Z into account, write $Z = Z_0(1-\beta t)$ and (34) will become, the products of small quantities being neglected,

$$\triangle_2\theta = \frac{-\,Z\,M\,(\alpha+\beta)\,t}{H\,M_0\,(1-\alpha t) - m\,g\,h} \tag{36}$$

The total drift, i. e. the total relative change in the position of the recording spot on the magnetogram, will be the combined effect of both loss of strength of the magnet and the secular change in Z, and the direction of the drift will be determined by the magnitude and sign of β.

Besides the vertical-intensity variometer having a single magnet as above, another type has a control magnet situated below the recording magnet with north end up. For this case

$$\theta = \frac{M\,Z - \dfrac{2\,M_0\,M_0'}{r^3} - m\,g\,c}{M\,H - m\,g\,h} \tag{37}$$

where r is the distance and M' the magnetic moment of the control magnet. The control magnet makes no change in the formulae for period and scale-value of the recording magnet.

Letting α and λ be the coefficients of loss of magnetism in the recording and control magnets respectively, (37) will become

$$\theta = \frac{Z\,M_0\,(1-\alpha t) - \dfrac{2\,M_0\,M_0'}{r^3}[1-(\alpha+\lambda)\,t] - m\,g\,c}{H\,M_0\,(1-\alpha t) - m\,g\,h} \tag{38}$$

If we impose the condition $\left(Z\,M_0 - \dfrac{2\,M_0\,M_0'}{r^3} - m\,g\,c\right) = 0$ at time t_0 we have

$$\triangle_3\,\theta = \frac{-\,M_0\,Z\,\alpha\,t + \dfrac{2\,M_0\,M_0'}{r^3}\,(\alpha+\lambda)\,t}{H\,M_0\,(1-\alpha t) - m\,g\,h} \tag{39}$$

Placing the numerator equal to zero and solving

$$\frac{2\,M_0'}{r^3} = \frac{Z\,\alpha}{\alpha+\lambda} \tag{40}$$

which will determine the distance and the strength of the control magnet required to counteract the loss of magnetism in the recording magnet. If $\alpha = \lambda$, (40) will be

$$\frac{M_0'}{r^3} = \frac{Z}{4} \tag{41}$$

If it were desired to take the secular change in Z into account, then introducing $Z = Z_0(1 - \beta t)$ into (39) and assuming the magnet was adjusted to be level at the start

$$\triangle_4 \theta = \frac{- Z_0\, M_0\, (\alpha + \beta)\, t + \dfrac{2\, M_0\, M_0'}{r^3}\, (\alpha + \lambda)\, t}{H\, M_0\, (1 - \alpha t) - m\, g\, h} \tag{42}$$

and the condition for eliminating drift would be

$$\frac{2\, M_0'}{r^3} = \frac{Z_0\, (\alpha + \beta)}{(\alpha + \lambda)} \tag{43}$$

which of course reduces to (40) when $\beta = 0$ and to (41) when $\alpha = \lambda$ also.

Equation (43) indicates the possibility of designing a vertical-intensity variometer which would be practically free from drift for any place where β is known, provided magnets possessing the required coefficients α and λ could be made or selected. The condition that $\alpha = \lambda$ could possibly be realized in practice by making the magnets from the same piece of steel, and magnetizing them in the same magnetizing coil at the same field intensity.

Let us assume $\alpha = \lambda$ and compute the strength of control magnet required to counteract the drift due to loss of magnetism, magnet J being used as a Z-variometer. Applying (41), the coefficients of loss of magnetism being equal, the control magnet M' at a distance of 14 cm. below, would have to be about 0.5 the size or volume of magnet J; moreover, if the temperature-coefficients of the magnets were equal the variometer would be compensated for temperature changes, and the recorded variations would require no correction for temperature. Thus a vertical-intensity variometer may, by means of a control magnet, be compensated either for drift in base-line values, or for temperature changes, provided the coefficients of loss of magnetism and the temperature coefficients are the same for both the recording magnet and the control magnet. This compensation can be effected by the appropriate adjustment of the distances c and r.

If $\alpha = \lambda$, the control magnet can be separated into two portions

$$M_0' = B + D \tag{44}$$

where $B = \dfrac{Z\, r^3}{4}$ from (41) and is that portion necessary to neutralize the drift due to loss of magnetism. Then using (44), (43) becomes

$$\frac{D}{B} = \frac{\beta}{\alpha} \text{ or } D = \frac{Z\,r^3\,\beta}{4\,\alpha} \qquad (45)$$

D is that portion of the control magnet effective in counteracting the secular change in Z. For example, for a secular decrease in Z of some 55γ per annum and so $\beta = 0.001$, a control magnet of about one half the size or volume of magnet J would be sufficient to counteract the decrease in Z: and in the example above, the same size of control magnet is sufficient to counteract the loss of magnetism. Hence, a control magnet of the same size as magnet J would be sufficient, under the conditions assumed, to counteract both loss of magnetism and of secular decrease in Z. If this control magnet were closer, or larger, the variometer would be over-compensated and the recording spot of light would drift upward on the magnetogram or in the positive direction of θ. On the other hand, if the control magnet were farther away, or smaller, under-compensation would ensue and the spot would drift downward in the negative direction of θ.

Besides movements of the magnet arising from magnetic changes, Z-variometers are sometimes subject to abrupt mechanical displacements. They are most likely to occur when the instrument is jarred, or when, as in making scale-value deflections, the deflecting magnet is brought up to or taken away from the instrument too quickly. In displacements due to jars, taking into consideration that the weight of the magnet is concentrated in the very small area of contact between the knife-edge and the agate plane, and that the pressure is thus very great, the knife-edge is probably injured or fractured and obstructed by the dust particles thrown in its way. Displacements or shifts due to deflecting the magnet indicate an imperfect knife-edge.

We may say, then, that the most important operating characteristics of the Z-variometer are: stability, sensitivity, and freedom from shifts. It would be of theoretical interest to investigate how these three characteristics are affected by imperfections in the knife-edge (fractured surfaces, for example) and by dust particles or other obstructions. However, it is clear these characteristics are vastly impaired by imperfections in the knife-edge; and on the other hand, both theory and experience have shown they may be secured by means of an accurately ground knife-edge.

In conclusion, it will probably be needless to emphasize the fact that a vertical-intensity variometer is an instrument of the greatest delicacy, and requires the utmost care in its operation. And in order that it may faithfully perform its function to record intensity changes of extreme minuteness, the knife-edge—the most important mechanical part of the instrument—must be maintained in the most perfect condition possible.

U. S. Coast and Geodetic Survey,
Cheltenham Magnetic Observatory,
May, 1918.

THE SECULAR VARIATION OF TERRESTRIAL MAGNETISM IN SIBERIA.

By Boris Weinberg.

PART I.—GENERAL CONSIDERATIONS.

There exists no summary of magnetic determinations actually made in Siberia. Hansteen's "Untersuchungen[1] ueber den Magnetismus der Erde" is now quite out of date, and Sabine's classical "Contributions to Terrestrial Magnetism," No. XIII[2], did not comprise the considerable amount of observations made in the first half of the seventies of the last century by Fritsche, Miller, and Scharnhorst, and, in this century, by Voznesenskij, Smirnov, the Author and his co-workers, and by other observers.

The insufficiency of even Sabine's work now can be easily seen, for instance, from Table I, which gives the number of magnetic observations in the zone of Siberia between parallels of latitude 45° and 60° North and between the meridians 60° and 135° East of Greenwich, either published or in press;[3] *D* denotes the magnetic declination, *I*, the inclination, and *H*, the horizontal intensity.

Table I.

Period	Total Number of				Total Number of New Points where was made			
	Independent Determinations			Points where Magnetic Observations were made	for the First Time a Determination of			any Magnetic Observation in General
	D	*I*	*H*		*D*	*I*	*H*	
Prior to 1825	24	6	0	13	11	5	0	13
1825–1864	170	250	236	235	124	192	198	222
1865–1894	202	204	195	190	135	126	124	144
1895–1917	624	368	362	627	586	185	264	518
Total........	1020	828	793	....	856	508	586	897

In order to know which regions of Siberia are most poorly explored magnetically as well as to know which points should be visited for the sake of evaluation of the secular variation, I began some years ago to arrange a card catalogue of magnetic determinations made in Siberia and contiguous countries. Each card of this catalogue contains the name of the point, its

[1]Christiania, 1819.

[2]*Phil. Trans.*, **162**, 1872.

[3]In order to avoid any unnecessary duplication of work I limited my investigations to the zone in question because the late V. C. Dubinskij last year was investigating the distribution of magnetic elements along the Siberian coasts of the Arctic and the Pacific and also had obtained many unpublished observations from the Russian Navy.

exact description, if any, its geographical coordinates, the date of observation or the epoch to which the latter was reduced and the results of observations for declination, inclination, horizontal intensity, and total intensity; everything was copied from the original paper or the original manuscripts. By means of this catalogue I have prepared a chart from which may be seen the distribution of the magnetic stations, each being marked by an asterisk composed of arrows or quadrants. The direction of each arrow, or quadrant, marks the element which has been determined and the number of the cross-lines at the point of the arrow indicates the period to which the determination belongs. Quadrant asterisks mark every one of the 257 points where determinations were made by the Physical Laboratory of the Technological Institute of Tomsk.

For declination, I had made, even as early as 1913, an attempt to obtain a reduction or more recent observations to the epoch 1909 and to construct a preliminary isogonic chart of Northern Asia for this epoch.[4] This attempt proved to be sufficiently successful. Although this chart contains in one place an isogonic line 2000 kilometers long and distant about 600 kilometers from nearest declination-stations, it gave values of D about $\pm$ 0°.5 correct as I convinced myself by comparing them with the results of our magnetic campaign of 1914[5] and of my expedition of 1915, in press.

Such a possibility of constructing a magnetic chart with very insufficient data as basis is owing to the fact that the magnetic elements, for the greater part of Northern Asia, vary quite regularly with latitude and longitude. Indeed, there are at present known only a few anomalous regions in Northern Asia—the mountains of the Altaj, the region around the Lake of Bajkal, the mountain region along Aldan in the Province of Jakutsk, the part of the Basin of the Jenisej River where it is squeezed between the mountains the last time before it reaches the ocean, and also a very few other points.

Although the number of magnetic stations is still very inconsiderable, the uniformity in the geographic variation of the magnetic elements suggests that the time is ripe for an attempt to summarize and reduce the available magnetic data for Siberia to a common epoch. Such a reduction necessitates a preliminary

[4] *Terr. Mag.*, vol. 19, p. 45, 1914.

[5] B. P. WEINBERG: *Izvestija (Bulletin) of the Techn. Inst. of Tomsk*, 39, 1918.

determination of the probable values of the secular variation; this problem can be attacked with still less chance of a successful solution than an evaluation of the probable distribution of terrestrial magnetism over Siberia. The truth of such assertion may be seen from Table II, which gives a summary of the number of points for which the secular variation for different periods of time may be determined, or rather, roughly evaluated. All cases where some point was a place of magnetic determinations distant in time less than 7 years were disregarded in constructing the table.

TABLE II.

From \ To	1910			1900			1890			1880			1870			1860			1850			1840		
	D	*I*	*H*	*D*	*I*	*H*	*D*	*I*	*H*	*D*	*I*	*H*	*D*	*I*	*H*	*D*	*I*	*H*	*D*	*I*	*H*	*D*	*I*	*H*
1830	35	37	32	10	6	3	3	6	2	1	1	0	12	15	14	0	0	0	1	1	0	0	0	0
1840	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	..	..	..
1850	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	..	..	..	..	..	..
1860	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	..	..	..	..	..	..	..	..	..
1870	34	31	34	5	7	6	4	6	3	4	5	2	..	..	..	..	..	..	..	..	..	..	..	..
1880	10	10	10	1	2	2	1	0	0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1890	9	7	9	2	2	0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1900	17	13	10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

The data of Table II contain not only points in the zone 45°-65° North and 60°-135° East, but also 5° beyond, in each direction. If we assume that, for a sufficiently probable determination of the secular variation for some period in a certain region, we must know the element in question at the beginning and the end of the period at points distant about 5° of latitude and about 10° of longitude, then for the zone 45°-65° North and 60°-135° East 63 points uniformly-distributed over the region would be necessary. Table II shows that in no case have we more than 37 points in a greater zone, and a closer investigation of the data shows that these points are distributed very ununiformly. Accordingly, an evaluation of the secular variation of terrestrial magnetism for Siberia is not a strictly physical or mathematical problem, but is nearer to a problem of paleontological character—to a problem of reconstruction of a whole if you know only some separate fragments of it. Such a paucity of resulting data should prevent even an attempt to solve the problem, if the chief purpose of its solution were the investigation of the secular variation in itself instead of the getting of practical means to reduce observations made at an anterior epoch to a posterior. The latter practical problem is not so hopeless because it is essentially and

in most cases an interpolation process, the correction to be applied to all the determinations of a certain observer being based on a comparison of the results of the same observer at certain of his stations with the results of posterior observations at the same stations. The remainder of the observer's stations usually lie between the latter repeat-stations. Only in few cases when at the outer regions of the zone, which is the object of our investigation, any corresponding posterior observations were lacking, my evaluations were necessarily extrapolations.

Nevertheless, although we restrict ourselves to such purely practical problem as to introduce in the observation-data the necessary corrections which would allow us to place on an iso-magnetic chart the observation-data at all the points where observations have been previously made, the results of such efforts can have a theoretical interest if such corrected anterior values, for points where posterior data are lacking, lie between posterior values for surrounding points. Indeed, if such a condition should exist we could with the same right reconstruct an iso-magnetic chart for an anterior epoch, using not only the results of observations made at that epoch but also the results of posterior observations referred to the anterior epoch. Using thus all the available observations the resulting chart might be sufficiently trustworthy, if the number of direct observations at the anterior epoch is not too small. The theroretical value of such charts resulting from a solution of a practical problem is obvious, as for example, for calculations based on Gauss's theory.

Wishing to give the results of my investigations of the secular variation of the magnetic elements in Siberia a practically convenient form, I tried to find, for nearly equidistant points and for equidistant epochs, the corrections to be applied to the observed values in order to reduce them to a standard epoch. For such an epoch I took 1910.0 and tried to find the corrections of D, I, and H for epochs 1830, 1840, 1850, 1860, 1870, 1880, 1890, and 1900 for points distant 2° in latitude and 5° in longitude, viz., for 45°, 47°, 49°, . . . 63°, and 65° latitude, and 60°, 65°, 70°, . . . 130°, and 135° longitude. For this purpose I have compared values of an element at stations where observations were made between 1909 and 1915 and at an anterior epoch. From such intercomparisons I interpolated corresponding differences $\triangle_{30}$, $\triangle_{40}$ . . . $\triangle_{00}$ for the nearest of the intervals 1830-1910, 1840-1910, . . . 1900-1910, and I plotted the results on three

special sheets in form of charts (for D, for I, and for H). These sheets made it possible to use intercomparisons for such points where last determinations were made at an epoch t prior to 1905 by adding to the observed difference a difference of the values of the element at the epoch t and at 1910 interpolated by means of the values of Δt already on the sheet for surrounding points.

But even after plotting on the sheets the results of all such intercomparisons I obtained only isolated islands, separated by vast blank spaces. Often even these islands gave a very unsatisfactory impression due to great differences in the values of D caused by the diversity of the instruments used by the different observers, by local disturbances, and the non-coincidence of the observation-stations, by insufficient accuracy of observation, etc.

The number of Δ_{40}, Δ_{50}, Δ_{60}, Δ_{80}, Δ_{90}, and Δ_{00} being much less than the number of Δ_{30} and of Δ_{70}, I took in consideration only the latter ones, and, after having selected, for regions where those were abundant enough, the more trustworthy, or taken the mean values, I have tried to adjust intermediate values, or to change the observed values so that only two conditions should be fulfilled. These conditions were: (1) The principles of continuity and smoothness of changes of magnetic elements in time and in space; (2) differences of observed and adjusted values of Δ_{30} and Δ_{70} not to exceed, if possible, about 30′ for declination, about 20′ for inclination, and about 0.0030 C. G. S. for horizontal intensity. These limiting values were approximate estimates of local influences and diversity of the instruments of two observers whose determinations are 40 or 80 years distant. I may mention at once that mean departures of the observed variations of D, I, and H from those which were computed, taking as point of issue my final tables, are $\pm 24'$ for D, $\pm 10'$ for I, and ± 0.0017 for H.

The adjustment was made simply by tedious successive trials, in order to obtain a smooth set as well of the values of the Δ as of their first differences for each horizontal row and for each vertical column of the table to be constructed. The values of Δ_{30} and Δ_{70} adjusted in this manner served to calculate the values of the rest of the Δ's by means of formulae:

$$\left.\begin{array}{l}\Delta_{49}=\frac{7}{4}\,\Delta_{70}+\frac{21}{32}\,\Delta;\ \ \Delta_{50}=\frac{6}{4}\,\Delta_{70}+\frac{12}{32}\,\Delta;\ \ \Delta_{60}=\frac{5}{4}\,\Delta_{70}+\frac{5}{32}\,\Delta\\ \Delta_{80}=\frac{3}{4}\,\Delta_{70}-\frac{3}{32}\,\Delta;\ \ \Delta_{90}=\frac{2}{4}\,\Delta_{70}-\frac{4}{32}\,\Delta;\ \ \Delta_{00}=\frac{1}{4}\,\Delta_{70}-\frac{3}{32}\,\Delta\end{array}\right\}\quad(1)$$

Δ being equal to $\Delta_{30}-2\Delta_{70}$. These formulae are simple interpolation-formulae based on the assumption that the variation of an element with time is a parabolic function of form $a+bt+ct^2$.

The calculations were made within 1′ for D and I and 0.0001 for H.

The first adjustment having been made, I compared the computed variations with the observed ones and once more readjusted the whole of the values obtained, taking sometimes into consideration also the observed values of Δ for intermediate epochs. The results are contained in future parts of this paper which give also particulars about the methods of treating the results of observation of different elements. Although these results for secular variation were thus obtained more or less much arbitrarily, they can *post factum* be regarded not only as intended to give practical means for reducing observed values to a certain epoch but as corresponding in some extent to reality.

I had the satisfaction to experience a proof of this assertion. The card catalogue mentioned above did not contain the observational results at magnetic observatories, the primary purpose of it being to know where and when magnetic measurements have been made at places other than observatories. After the work of readjustment had been completed, I incidentally saw Mielberg's paper on "Die Magnetische Declination in Jekaterinburg, Barnaul, und Nertschinsk"[6] and decided to consider also the results of magnetic determinations tabulated in this paper, but before a new readjustment I made a reduction to 1910 of the values of D given there by means of the Δ contained in my table. The results are given in Table III, east declination being counted as negative.

Table III.

Epoch	Ekaterinburg			Barnaul			Nertschinsk		
	D_t	Δ_t	D_{1910}	D_t	Δ_t	D_{1910}	D_t	Δ_t	D_{1910}
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
1843	−6 49	−4 13	−11 02	−8 31	−2 29	−11 00	+3 49	+2 04	+5 53
1848	−7 15	−3 51	−11 06	−8 46	−2 14	−11 00	+4 00	+1 57	+5 57
1853	−7 37	−3 29	−11 06	−8 54	−2 04	−10 58	+4 06	+1 50	+5 56
1858	−7 51	−3 08	−10 59	−9 05	−1 52	−10 57	+4 10	+1 43	+5 53
1862	......	......	....	......	......	....	+4 23	+1 37	+6 00
1863	−8 11	−2 47	−10 58	−9 28	−1 40	−11 08	......	......	......
1868	−8 33	−2 28	−11 01	−9 41	−1 28	−11 09	......	......	......
1872	......	......	....	−9 51	−1 20	−11 11	......	......	......

The satisfactory agreement in the values of D_{1910} indicated that a new readjustment was superfluous. I came to the same con-

[6] *Repertorium für Meteorologie*, V, N. 3, 1876.

clusion after reducing by means of my tables the data contained in Müller's papers on "Die Beobachtungen der Inclination[7] im Observatorium zu Katharinenburg von 1837-1885" and on "Die Beobachtungen der Horizontal-Intensität[8] des Erdmagnetismus im Observatorium zu Katharinenburg von 1841-1889." This may be seen from Table IV, although the variability of H was in Ekaterinburg much less than I assumed by comparing the observations of different field observers.

TABLE IV.

t	I_t	Δ_t	I_{1910}	t	I_t	Δ_t	I_{1910}	t	H_t	Δ_t	H_{1910}
	° ′	° ′	° ′		° ′	° ′	° ′		c.g.s.		c.g.s.
1838	69 59	+1 23	71 22	1868	70 17	+0 57	71 14	1858	.1791	−67	.1724
1843	69 58	+1 19	71 17	1873	70 18	+0 51	71 09	1874	.1787	−50	.1737
1848	70 03	+1 15	71 18	1878	70 25	+0 45	71 10	1881	.1785	−41	.1744
1853	70 08	+1 11	71 19	1883	70 29	+0 38	71 07	1886	.1782	−34	.1748
1858	70 14	+1 07	71 21	1889	70 36	+0 30	71 06	1889	.1781	−31	.1750
1863	70 17	+1 02	71 19	....	.....	......	.....	....	.....	....	.....

Therefore the tables of the differences to be applied to the observed values of the magnetic elements in order to reduce them to the epoch of 1910, which are given in the following parts of this paper, can be looked upon as representing the summary of our knowledge about the secular variation of terrestrial magnetism in Siberia, and their uncertainty must be attributed in a much greater degree to the incompleteness of our knowledge rather than to the method of treating the very insufficient material.

PART II.—SECULAR VARIATION OF DECLINATION.

The results for magnetic declination in Siberia are much less reliable than those of inclination and of intensity. This circumstance is a matter of fact but can be in some extent explained by the incorrectness of the values of geographical coordinates adopted by the observers of the old times. I found differences between the old values and the more recent ones up to 1° for latitude and up to 2° for longitude. But there were also found great differences in declinations as given by different observers whose determinations nearly coincide in time for stations with correct values of latitude and longitude. Such differences can be partly attributed to diurnal variations but they also indicate the presence of local

[7] *Repertorium für Meteorologie*, XII, N. 12, 1889.

[8] *Repertorium für Meteorologie*, XIV, N. 3, 1891.

disturbances. As a striking illustration I may mention Tobolsk for which Hansteen (1828) gives $D = -9° 46'$; Erman (1838) in three different places found $-9° 38'$, $-9° 46'$ and $-9° 55'$, Fuss (1830) obtained $-11° 52'$, and Federov (1833), $-10° 20'$.

Concerning local disturbances we may predict theoretically that they must affect values of declination rather more than those of inclination, or of horizontal intensity. In order to prove such a statement let us consider a local disturbing influence which creates at the observation-station a field of a certain intensity f and of a certain direction. If we admit every direction of f as equally possible the probable mean absolute value of the deflection $\triangle H$ of the horizontal intensity from its normal value will be given by the following formula:

$$\triangle H = \frac{1}{2\pi}\int_0^{2\pi}\int^{\frac{\pi}{2}} f \cos\phi \sin\phi \, d\phi \, d\psi = \frac{1}{2}f \tag{2}$$

The meaning of ϕ and ψ being obvious from Fig. 1 and the integration being extended over the hemisphere whose base is vertical and perpendicular to the direction of H.

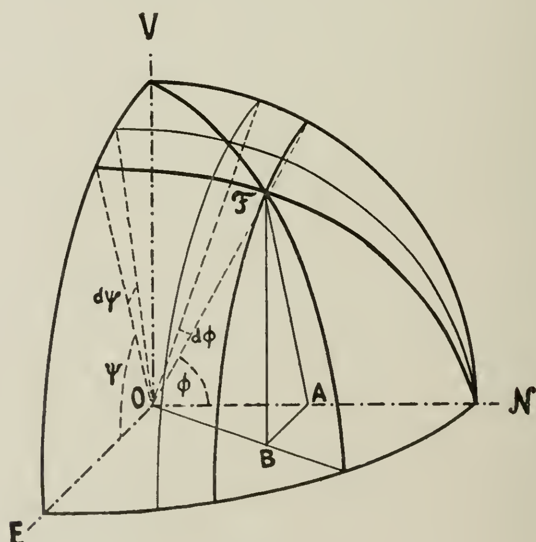

Fig. 1.

In a similar manner the probable mean absolute value of $\triangle D$ which can be caused by such a field every direction of which is equally possible is derived from the formula:

$$\triangle \operatorname{tg} D = \frac{1}{2\pi}\int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}}\int_0^{\pi}\frac{f\sin\phi\cos\psi\,.\,\sin\phi\,d\phi\,d\psi}{H+f\cos\phi} =$$

$$= \frac{2}{\pi}\left\{\frac{\pi}{2}\left(\frac{H}{2}-\frac{H}{f}\sqrt{1-\frac{f^2}{H^2}}\right)+\sqrt{\frac{H^2-f^2}{f^2}}\operatorname{arctg}\sqrt{\frac{f^2}{H^2-f^2}}-1\right\} \quad (3)$$

The integration being extended over the hemisphere whose base is vertical and coincides with the magnetic meridian. If we assume f small in comparison with H and neglect higher powers of f/H we have

$$\triangle \operatorname{tg} D = \frac{f}{2H} - \frac{2f^2}{3\pi H^2} + \frac{f^3}{8H^3} - \frac{16f^4}{15\pi H^4} + \ldots . \quad (4)$$

Taking only the first member we have

$$\triangle D = \frac{f}{2H} \quad (5)$$

This result could be predicted from formula (2), the latter showing that the mean absolute value of the component of f in some definite direction, H being one of such directions, is equal to $\frac{1}{2}f$. If indeed we take into account that the mean absolute value of the component of f in the direction OE is also $\frac{1}{2}f$, we can directly obtain the formula (5).

In the same way by integration over a hemisphere whose base is perpendicular to the magnetic meridian and includes the direction of total intensity T we obtain

$$\triangle \operatorname{tg} I = \frac{f}{2T} - \frac{2f^2}{3\pi T^2} + \ldots . \quad (6)$$

or approximately

$$\triangle I = \frac{f}{2T} = \frac{f\cos I}{2H} = \triangle D\cos I \quad (7)$$

It is thus seen that $\triangle I$ must be less than $\triangle D$, and less in greater degree the larger the value of I. For Siberia, and $f = 0.0020$ C. G. S., formulae (2), (5), and (7), for instance, give for latitude 45°, $\triangle D = 14'$ and $\triangle I = 7'$; for latitude 55°, $\triangle D = 18'$ and $\triangle I = 6'$, and for làtitude 65°, $\triangle D = 30'$ and $\triangle I = 6'$.

In order to see whether the assumptions which led me to formulae (2), (5), and (7) correspond in some extent to reality, I have used the following observation-data:

1. Determinations at fundamental and auxiliary points made in many places by the observers of the Department of Terrestrial Magnetism of the Carnegie Institution ("Land Magnetic Observations 1905–1910", Washington, 1912,

pp. 58–100, and "Land Magnetic Observations 1911–1913 and Reports on Special Researches", Washington, 1915, pp. 26–64);

2. Determinations at Petropavlovsk I and II, at Krasnojarsk I and II, and at Vladivostok I and II made by Smirnov in 1909 (Bull. Acad. St. Petersb., 1910, pp. 841–846).

3. Observations of various authors (Hansteen, Due, Erman, Fuss, Fedorov) at the same places in Siberia, 1828–1835.

For each of these three groups of determinations I compared the values of declination for different points of the same place, if the observations were not far distant in time, and took the difference of the values, if there were only two values, or the mean of the differences of the values, if their number exceeded two.

The first group gives the values of D without any correction for diurnal variation so that the calculated differences include not only the influence of local disturbances but also the daily variation. But if we take a sufficient number of observations, or of points, the latter effect may be practically eliminated in the mean. I have taken at first only such points which were not marked by an asterisk accompanied by the words, "local disturbance," and also excluded such points where such "local disturbance" was as obvious as at points marked by an asterisk, although the latter was absent. The results of my computations are contained in the left half of Table V and are grouped there in accordance to the limits of I. The right half of the same table contains similar data calculated from the results of observations at all the points—without "local disturbances" or with such—except evidently anomalous points: Mount Magnet (Land Magnetic Observations 1911-1913, p. 38), Bayswater (*l. c.*, p. 39) and Commonwealth Bay (*l. c.*, p. 63).

TABLE V.

I	NORMAL POINTS				ALL THE POINTS			
	No.	$\triangle H$	$\triangle D$	$\triangle I$	No.	$\triangle H$	$\triangle D$	$\triangle I$
° °		c.g.s.	′	′		c.g.s.	′	′
0—15	18	.0003	2	5	21	.0007	9	8
16—30	6	.0002	1	2	9	.0003	3	6
31—45	23	.0002	2	3	25	.0009	5	7
46—60	26	.0005	6	4	31	.0011	13	13
61—75	20	.0008	8	3	24	.0008	12	4
76—90	6	.0007	11	6	8	.0012	56	8

Smirnov's values, although not numerous, are corrected for diurnal variation and, therefore, are more suited for our purpose. The results of old observations are much more distant in time, were made with different instruments, and, for declination, are differently corrected for the inexact values of latitude and longitude adopted by the authors. Therefore a comparison of their results may easily give a more exaggerated value of the influence of local disturbances.

Table VI gives the summary of the comparison of the results for all the three groups of observations. Concerning the first group, I took the right half of Table V and joined all the points in 3 groups instead of 6. Besides the mean differences of observed values, the table contains the calculated values which I have computed by means of the formulae (2), (5), and (7), taking for f, 0.0020 C. G. S., and for I and H, the mean observed values I_m and H_m given also in Table VI.

TABLE VI.

OBSERVERS	No.	I_m	H_m	$\triangle H\ 10^4$		$\triangle D$		$\triangle I$	
				Obs.	Calc.	Obs.	Calc.	Obs.	Calc.
		°				′	′	′	′
C. I. W., $I>30°$	30	15	.32	6	10	7	11	8	10
" " " $30°>I>60°$	56	45	.30	10	10	10	12	10	8
" " " $60°>I$	32	70	.20	9	10	20	17	5	6
Smirnov, 1909	3	67	.21	14	10	17	16	3	6
Various, 1828—35	22	65	.20	8	10	28	17	9	7

The agreement of the observed and calculated values of $\triangle D$ and $\triangle I$ is much greater than I had expected before making the calculations and shows at the same time that the presumption of $f=0.0020$ C. G. S. as a measure for the probable mean value of the influence of local disturbances is not far from reality for different regions of the globe.

On account of the greater uncertainty in the values of declination, it was difficult to adjust the observed values of $\triangle_{30}$ and $\triangle_{70}$ for declination to a certain smoothness. Especially difficult was the region between 80° and 110° of longitude where the observed $\triangle_{30}$ were found to vary very rapidly and rather irregularly.

The results of the final adjustment of $\triangle_{30}$ and $\triangle_{70}$ and of calculation of $\triangle_{40}$, $\triangle_{50}$, $\triangle_{60}$, $\triangle_{80}$, $\triangle_{90}$, and $\triangle_{00}$ are contained in Tables VII and VIII, which give the correction, in minutes, to be

Table VII.

Long. / Lat.	60°		65°		70°		75°		80°		85°		90°		95°		100°	
°	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
65	...	...	357	169	355	165	344	156	329	145	304	126	266	101	...	64	...	31
	...	...	308	125	305	122	294	114	280	105	255	90	219	70	...	43	...	18
	...	...	260	82	257	80	246	74	233	68	209	57	176	42	...	25	...	9
	...	...	214	40	210	39	200	36	188	33	166	27	136	19	...	11	...	3
63	...	...	343	160	337	153	326	144	310	130	278	113	242	91	...	54	...	29
	...	...	295	118	288	112	277	104	260	93	232	80	198	63	...	42	...	18
	...	...	249	77	241	73	230	67	214	59	189	50	159	39	...	25	...	9
	...	...	204	38	196	35	186	32	170	28	149	23	123	18	...	11	...	3
61	335	160	230	151	320	142	308	133	290	117	255	101	217	83	168	60	...	24
	290	119	282	110	272	103	261	96	242	83	212	71	179	57	137	40	...	14
	246	79	237	72	227	66	215	61	197	52	172	44	144	35	108	24	...	7
	202	39	193	35	183	32	173	29	155	24	135	20	112	16	83	10	...	2
59	323	151	318	142	306	133	291	123	269	109	292	93	142	53	191	75	64	16
	278	111	271	103	259	96	244	88	224	77	193	66	117	37	157	52	49	9
	244	73	226	67	214	61	201	56	183	48	157	41	127	32	94	22	36	4
	192	36	183	32	172	29	161	27	144	22	123	19	100	15	72	10	25	...
57	315	141	306	133	292	125	272	114	247	102	212	87	163	68	105	44	36	6
	268	103	259	96	247	90	228	81	208	71	177	62	135	48	89	31	26	2
	224	66	214	61	203	57	187	51	171	44	145	39	111	31	73	20	18	0
	181	32	172	29	163	27	149	24	136	20	115	18	88	14	58	10	11	
55	311	132	296	125	277	117	252	106	223	95	192	83	135	61	73	33	13	
	262	95	249	90	233	84	212	76	189	68	162	60	116	44	63	24	6	
	216	61	205	57	192	53	174	48	156	43	134	39	97	28	53	16	1	
	172	29	163	27	153	25	139	23	124	21	108	19	79	13	43	8		
53	314	124	288	118	263	112	234	104	203	104	170	80	114	57	54	24		
	261	87	241	84	222	80	199	76	174	68	146	59	100	43	46	17		
	211	54	197	53	183	51	166	49	146	44	123	38	86	28	38	11		
	165	25	156	25	146	24	134	24	119	21	101	19	72	14	31	5		
51	320	117	284	112	249	106	215	99	180	91	139	78	93	55	39	18		
	261	80	234	78	209	76	184	72	158	68	126	60	84	42	34	13		
	208	48	188	47	173	49	155	47	136	46	112	41	76	29	28	9		
	159	21	148	22	138	23	127	23	114	23	96	21	66	15	23	4		
49	...	111	...	106	...	101	200	95	156	87	108	76	...	53	...	13		
	...	75	...	74	...	72	173	70	144	68	104	62	...	43	...	11		
	...	43	...	44	...	45	146	46	132	46	98	44	...	31	...	8		
	...	19	...	20	...	21	120	23	104	24	89	23	...	16	...	5		
47	...	105	...	100	...	95	...	90	...	84	...	75	...	53	...	15		
	...	69	...	69	...	68	...	67	...	66	...	61	...	44	...	15		
	...	39	...	41	...	43	...	44	...	46	...	44	...	32	...	12		
	...	16	...	18	...	20	...	22	...	24	...	24	...	17	...	7		
45	...	98	...	93	...	90	...	85	...	80	...	74	...	54	...	21		
	...	61	...	63	...	64	...	65	...	63	...	60	...	46	...	21		
	...	33	...	37	...	40	...	43	...	46	...	44	...	34	...	17		
	...	13	...	16	...	19	...	22	...	24	...	23	...	19	...	10		

TABLE VIII.

Lat. \ Long.	100°		105°		110°		115°		120°		125°		130°		135°	
°	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'
65	...	...	...	3	...	55	...	122	359	177	422	215	...	...	...	...
	...	...	...	5	...	43	...	93	313	132	371	162	...	...	...	...
	...	...	...	5	...	30	...	65	267	88	319	108	...	...	...	...
	...	...	...	4	...	16	...	31	222	44	267	54	...	...	...	...
63	...	...	...	12	...	57	...	115	326	163	387	196	425	219	425	229
	...	...	...	15	...	45	...	87	285	122	340	148	375	165	379	175
	...	...	...	12	...	31	...	58	245	82	292	99	324	111	331	118
	...	...	...	7	...	16	...	29	204	41	244	50	272	56	281	60
61	...	...	...	22	...	59	203	108	291	148	349	177	385	198	389	207
	...	...	...	19	...	46	181	83	256	111	307	133	339	145	346	157
	...	...	...	15	...	32	158	56	220	74	265	89	293	100	301	106
	...	...	...	8	...	17	133	28	184	37	221	45	224	50	255	54
59	...	...	15	29	99	62	184	101	256	133	310	159	342	177	350	185
	...	...	22	25	92	48	165	78	226	101	273	120	301	134	311	141
	...	...	27	20	83	33	145	53	195	68	236	81	260	90	270	95
	...	1	29	11	73	17	123	27	164	34	198	41	219	46	228	48
57	...	...	29	34	98	63	165	94	222	119	270	142	300	157	311	164
	...	...	34	29	91	50	149	73	199	90	239	107	265	119	276	125
	...	...	36	21	84	35	132	50	174	61	207	72	230	80	239	84
	...	1	35	12	75	18	114	26	147	31	175	36	194	41	202	43
55	...	5	45	39	97	64	147	87	192	107	231	125	257	136	271	143
	...	6	46	33	91	50	134	62	171	82	206	96	228	104	241	108
	...	5	45	25	83	36	120	40	152	56	180	65	198	70	209	73
	2	3	43	14	74	19	105	19	131	29	153	33	167	36	177	37
53	5	17	55	44	96	64	131	80	164	95	194	108	216	117	230	122
	9	14	54	35	91	50	121	63	150	73	175	82	193	89	205	93
	13	12	53	25	83	36	109	44	133	50	154	55	169	60	178	63
	15	7	50	13	74	19	95	23	115	26	132	28	144	30	151	32
51	19	22	65	47	95	62	115	72	135	82	155	91	174	100	...	108
	22	19	63	38	90	49	107	57	125	64	142	71	159	77	...	83
	23	15	60	27	82	34	97	40	112	45	127	49	142	53	...	57
	23	8	54	15	73	18	85	21	98	23	111	25	123	27	...	29
49	...	25	75	48	94	59	102	62	110	65	...	68	...	71	...	74
	...	20	70	39	87	46	94	49	101	51	...	54	...	57	...	59
	...	14	64	27	80	32	85	34	90	36	...	39	...	41	...	43
	...	8	57	14	70	16	74	18	78	19	...	20	...	21	...	22
47	...	21	83	45	93	50	99	48	...	45	...	42	...	38	...	35
	...	14	74	34	83	38	86	36	...	35	...	32	...	29	...	26
	...	8	65	23	73	26	73	24	...	24	...	22	...	19	...	17
	...	3	55	12	62	13	60	12	...	12	...	11	...	10	...	8
45	...	7	88	26	91	32	94	22	...	15	...	10	...	4	...	1
	...	1	69	16	74	21	71	13	...	7	...	4	...	2	...	0
	...	2	53	9	58	12	52	5	...	2	...	1	...	0	...	4
	...	3	38	3	44	5	35	1	...	0	...	0	...	0	...	1

added algebraically to the observed value of D. All corrections in Table VII have the negative sign, the reduction of the observed negative, or *east*, values of D to the epoch 1910.0, accordingly, making the numerical values of D greater. All corrections in Table VIII have the positive sign, the reduction of the observed positive, or *west*, values of D to the epoch of 1910.0, accordingly, making the numerical value of D greater. The demarcation line of the two tables is some 10° to the west of the agonic line so that in most cases the reduction to 1910 makes the numerical value of D greater. This circumstance indicates that the isogonic lines, between 1830 and 1910, were approaching each other; this decade seems to show the opposite.

PART III.—SECULAR VARIATION OF INCLINATION.

The theory and practice of the observations with the dip circle were sufficiently developed even in the third decade of the last century so that the instrumental errors could be much more easily eliminated in the measurements of the inclination than in the determinations of the declination or of the horizontal intensity. The inclination, as we have seen, is less subject to the influence of the local disturbances, and the diurnal variation of I in Siberia may be practically neglected. On account of all these reasons we must expect that the data for secular variation of inclination will be subject to irregularities in a less degree than is the case for the declination.

These considerations are confirmed by the observation-data as may be illustrated, for instance, by the case of Tobolsk. The values of D given by the various observers of the thirties are widely discordant (see Part II), whereas the values of I are much more concordant for this place. Thus, Hansteen (1828) gives $I = 70° 58'$, Erman (1828), 71° 07′, Humboldt (1838), 70° 56′, Fuss (1830), 71° 02′, and Fedorov (1833), 71° 02′.

The arrangement of Tables IX and X are analogous to that of Tables VII and VIII with the slight difference that, owing to much lesser changes of I with longitude, the values of the secular variation for longitudes over 100° are given for every 10° instead of every 5°. Tables IX and X give the correction to be added to the observed value of I in order to reduce it to the epoch 1910.0. All the corrections are in minutes and positive except very few cases when they are negative, these being marked by the minus sign; the plus sign is omitted throughout.

TABLE IX.

Lat. \ Long.	60°		65°		70°		75°		80°		85°	
°	′	′	′	′	′	′	′	′	′	′	′	′
65	....	....	33	5	50	16	65	27	76	36	83	41
	....	....	24	1	40	11	54	19	65	27	72	30
	....	....	16	−1	31	6	44	12	55	18	62	20
	....	....	10	−1	23	2	35	6	45	9	51	10
63	....	....	40	10	55	21	69	31	81	40	89	45
	....	....	31	5	45	15	59	23	70	30	78	34
	....	....	23	2	36	9	49	15	60	20	67	23
	....	....	16	0	28	4	40	7	50	10	56	12
61	42	10	53	20	65	29	76	37	86	45	95	49
	32	5	44	14	55	21	66	27	77	34	84	37
	23	2	35	9	46	13	56	18	67	23	73	25
	16	0	27	4	37	6	46	9	56	12	61	13
59	60	28	70	35	79	41	87	46	96	50	102	53
	52	21	61	27	70	31	77	35	85	37	90	40
	44	14	52	18	60	21	67	24	74	25	78	27
	36	7	44	9	51	11	57	13	62	12	66	14
57	85	52	92	55	97	57	104	59	109	60	112	59
	79	40	85	43	88	45	94	46	98	46	99	45
	71	28	76	30	79	31	83	31	86	31	86	30
	62	14	66	16	69	16	72	16	73	16	73	15
55	106	73	111	73	114	69	116	67	118	65	120	63
	101	59	104	56	105	54	105	52	106	50	106	47
	94	42	95	40	95	38	94	36	93	34	92	32
	85	22	84	21	83	20	81	19	79	18	78	16
53	124	86	128	83	129	79	128	74	126	69	127	64
	119	69	121	65	121	62	118	57	113	53	111	48
	111	49	111	46	109	43	104	39	99	36	96	32
	100	26	98	24	95	23	90	20	84	18	80	16
51	....	94	....	90	....	85	136	78	135	72	134	66
	....	74	....	71	....	67	122	60	120	55	118	49
	....	52	....	49	....	46	106	41	104	37	100	33
	....	27	....	26	....	24	96	21	88	19	82	16
49	....	98	....	94	....	88	146	81	143	74	141	67
	....	77	....	73	....	68	132	62	126	56	122	49
	....	54	....	51	....	47	117	42	119	38	103	32
	....	28	....	26	....	24	100	22	92	19	84	16
47	....	99	....	96	....	90	....	83	....	76	....	68
	....	77	....	74	....	69	....	63	....	57	....	49
	....	53	....	51	....	47	....	42	....	38	....	32
	....	27	....	26	....	24	104	22	95	19	88	16
45	....	100	....	97	....	92	....	85	....	77	....	68
	....	76	....	74	....	69	....	63	....	57	....	49
	....	52	....	50	....	46	....	42	....	37	....	32
	....	26	....	25	....	23	107	21	97	18	89	15

TABLE X.

Lat. \ Long.	90°		95°		105°		115°		125°		135°	
°	′	′	′	′	′	′	′	′	′	′	′	′
65	86	40	86	35	84	27	80	22	74	19	65	17
	74	29	71	25	67	17	62	14	57	11	50	10
	62	19	58	16	52	10	47	7	43	5	37	5
	51	9	46	8	39	4	34	3	30	2	26	1
63	93	46	93	42	94	36	95	29	92	24	89	22
	81	34	79	31	77	25	75	18	71	14	68	12
	69	22	66	20	62	15	57	9	53	7	50	5
	58	11	54	9	48	7	42	3	37	2	34	1
61	100	50	100	48	103	44	105	38	107	31	107	26
	87	37	86	36	87	32	86	26	84	19	82	14
	75	25	73	24	72	20	68	15	64	10	60	7
	62	12	60	12	57	10	52	7	46	4	41	1
59	107	55	107	53	110	50	113	46	117	39	118	29
	94	41	93	39	94	37	94	32	94	25	90	16
	81	28	79	26	79	24	77	20	73	15	66	7
	68	14	66	13	64	12	61	9	55	6	45	1
57	114	58	115	56	119	53	122	49	123	41	124	30
	100	43	100	42	101	39	102	35	99	27	95	17
	86	29	85	28	84	25	83	22	77	15	69	7
	72	15	70	14	68	12	65	10	57	6	48	2
55	121	61	122	58	123	54	124	48	125	40	124	30
	106	46	105	43	104	39	101	34	99	25	95	17
	91	31	89	29	86	25	82	21	77	14	69	7
	76	15	72	14	68	12	63	10	57	5	48	2
53	127	60	128	58	127	53	126	46	126	38	....	28
	110	44	109	43	107	39	103	31	95	26	....	21
	93	29	91	28	87	24	82	19	73	15	....	11
	76	14	74	13	69	11	63	8	55	7	....	6
51	133	60	132	57	130	51	128	43	127	35	....	25
	115	44	112	41	107	34	103	28	98	21	....	14
	96	29	91	26	86	22	80	16	74	10	....	5
	77	14	73	12	68	10	61	7	53	4	....	2
49	139	60	137	55	133	48	130	39	128	31	....	21
	118	43	114	38	108	33	102	25	97	17	....	9
	98	28	93	24	85	20	78	13	71	7	....	1
	78	13	73	11	65	9	57	5	49	2	....	−1
47	....	60	143	54	136	44	132	34	129	26	....	16
	....	43	118	37	108	28	102	20	96	12	....	4
	....	27	95	22	84	16	75	9	68	3	....	−3
	78	13	73	10	62	6	53	3	44	−1	....	−5
45	....	59	148	53	138	40	134	30	130	20	....	....
	....	42	122	36	108	25	101	16	81	8	....	....
	....	26	97	21	82	13	73	6	56	1	....	....
	79	12	73	9	59	5	49	1	36	−1	....	....

PART IV.—SECULAR VARIATION OF HORIZONTAL INTENSITY.

The greatest difficulty in determining secular changes of horizontal intensity is the uncertainty of the constants of the instruments used by different observers, although the methods of observation and their immediate results were as good 80 years ago as now. This circumstance does not essentially affect the reduction of observations to a posterior epoch made for the purpose of establishing the distribution of intensity. Indeed an incorrect value of the constant of the instrument of an observer will make incorrect the value of the correction $\triangle H$ to be applied to his observations in order to reduce them to a posterior epoch but not the corrected values of H reduced to the epoch

The observations of different authors which I have used for computing the following Tables XI and XII have always been taken from original data except for the observations of Erman (1828-1829), Fuss (1830-1832), Fedorov (1833-1835), and Scharnhorst (1875).

A. The results of Erman are given in his book "Reise um die Erde . . ." (Berlin, 1841) in Humboldt or arbitrary units (Willkürliche Einheiten), which were used in the beginning of the past century; those in Hansteen's book "Resultate Magnetischer, Astronomischer, und Meteorologischer Beobachtungen . . ." (Christiania, 1863) are given in Gaussian units, and those in Sabine's work are given in British units.

Hansteen's figures are not the result of a simple multiplication of Erman's values by a definite reduction-coefficient but are based on a recomputation of the rate of diminution of the magnetic moment of Erman's magnets. Sabine's figures correspond mostly to the figures of Hansteen recalculated by means of the usual reduction-factor 0.56108; there are some exceptions which must be attributed either to misprints or to errors of computation.

Thus, for example, for the region covered by the present investigation Sabine gives erroneous data as follows: (1) For Tobolsk (p. 393) a value of total intensity, F, is given as determined by Humboldt although the latter made only determinations of inclination ("Central Asien, II, pp. 266–293, 1849); (2) The values observed by Fuss at Kurbinsk are given twice (p. 389) for different values of longitude, viz, 106° 53′ and 111° 03′, and therefore with different values of correction to 1842.5; (3) The values observed by Hansteen at Baikinskoie are given (pp. 404 and 411) both for the Zone V and for the Zone VI with two slightly different values of latitude, viz, 64° 59′ and 65° 00′; (4) On pages 362 and 399 are given as values observed by Erman at Ačinsk, Botoi, and Bolše-Urinsk, and by Fuss at Zair-Ussu and Šara-Muren the values which Fritsche (*Repertorium für*

Meteorologie **1**, 1870), for the sake of comparison with his own posterior observations, interpolated from the observations of Erman and Fuss in adjoining regions, although no observations were made by them at these points; (5) The same seems to be the case for observations quoted by Sabine as made by Erman at Zima (p. 389) and at Tiukalinsk (p. 397) where Erman made no observations; (6) For both Pokrovsks, $\phi = 54° 29'$, $\lambda = 74° 00'$, and $\phi = 55° 42'$, $\lambda = 77° 28'$, Sabine gives results of observations of Erman with the same values of inclination but with different values of total intensity, although Erman made determinations only at the latter point.

I have therefore accepted for the results of Erman the values as given by Hansteen.

B. The results of Fuss[9] are given by him in Humboldt units, by Hansteen (*l. c.*) in Gaussian units, and by Sabine in British units. Sabine's figures being a simple recalculation of Hansteen's values, we have to deal only with the values given by Fuss himself and with the values which result from the recomputations of Hansteen. Both authors base their calculations on comparisons of oscillation observations of Fuss in 1830-1832 with Hansteen's determinations of horizontal intensity at the same points. I must point at once that such a method is a reduction of the observations of Fuss to the epoch 1829.

Fuss himself took for his observations of 1830-31 as the point of comparison the station Troickosavsk, assuming there $F = 1.6422$ and for the observations of 1832, the station Irkutsk, assuming at this point $F = 1.6466$, these two values being given by Hansteen in Humboldt units in a preliminary communication. Hansteen takes for the same points the values $F = 5.7714$ and 5.79915 which were given as final by him in absolute units in his book; he finds from these values the logarithm of the reduction-coefficient equal to 0.54632 and uses it for recomputing Fuss's observations of 1830-31.[10] In order to recompute Fuss's observations of 1832 Hansteen compares his own final values of F at Verchneudinsk and Selenginsk, viz., 5.6952 and 5.7616, with the values given by Fuss for the same points, viz., 1.6569 and 1.6620, thus obtaining the logarithm of the reduction-coefficient equal to 0.53806 and uses this value for recalculating Fuss's observations of 1832.

Let us compute by means of these two Hansteen reduction-coefficients the values of F in arbitrary units for the only common point of Fuss's observations of 1830-1831 and of 1832, viz., Irkutsk, for which Fuss gives different values of inclination but the same value, 1.6466, of total intensity without indicating at what time the observations of oscillations were really made. In this way we obtain for the total intensity at Irkutsk 1.6487 and 1.6800 respectively, the latter value widely differing from the value 1.6466 taken by Fuss as the basis for reduction of all his observations of 1832.

[9] *St. Peterburg, Mém. Ac. Sc.*, **IV**, 1. partie, 1838 (59-128).

[10] Hansteen erroneously gives logarithm of 1.6466 as 0.216388 instead 0.216588 which would change logarithm of the reduction-coefficient to 0.54622.

I therefore decided to follow the example of Hansteen and to use the values of F given by Fuss at the four common points but to compare them not only with Hansteen's determinations but also with the determinations of Erman (recalculations by Hansteen) at the same points, giving to the latter smaller weight than to those of Hansteen but making no difference in weighting for the two expeditions of Fuss.

For Irkutsk, Hansteen gives as the result of his and Due's determinations $F=5.79915$; from Erman's determinations we have 5.756; as the mean value we shall adopt 5.785, wherefrom $\log K=0.54475$; for Troickosavsk the corresponding values of F are 5.7714, 5.721, 5.755, and $\log K=0.54463$; for Verchneudinsk, 5.6952, 5.679, 5.690, and $\log K=0.53582$; for Selenginsk Hansteen gives F equal to 5.7616 and we have $\log K=0.53991$. The most trustworthy of these four values of $\log K$ is the one derived from determinations at Irkutsk because Fuss definitely says "wo Hansteen"; the least trustworthy is the value from determinations at Selenginsk where the value of inclination given by Fuss differs greatly from Hansteen's and where according to the statement of Fuss himself the observations "scheint ein nachtheiliger Einfluss eingewirkt zu haben." Giving therefore to the value of $\log K$ for Irkutsk weight 4, for Troickosavsk and Verchneudinsk weight 2, and for Selenginsk weight 1, we obtain finally $\log K=0.54263 \pm 0.00201$. This mean error corresponds to a half of one per cent for values of F and H (or nearly 0.001 C. G. S. for values of H) and is of the same order of magnitude as the mean difference of Hansteen's and Erman's results.

C. Fedorov's observations ("W. Fedorow's Vorläufige Berichte . . ." herausgegeben von F. G. W. Struwe, St. Petersburg, p. 179, 1838) were disregarded by Sabine, as well as by Tillo (*Repertorium für Meteorologie* **IX,** N. 5, p. 77, 1885) on account, I think, of Fedorov giving only the quotients of the time of oscillation of his magnet at different stations and the time of its oscillation at Tobolsk, both being reduced to the same temperature, etc. I tried to compute for stations where observations were made by Fedorov and also by Hansteen the values of log $\left[H_{\text{Hansteen}} \times \left(\frac{T}{T_{\text{Tobolsk}}}\right)^2\right]$. For five stations where observations were made between 1832 and 1834, viz., Omsk, Jamyševo, Bogoslovsk, Ekaterinburg, and Tobolsk, I obtained values whose mean difference on this arithmetical mean, 0.2532, was only 0.0010, corresponding to one quarter of one per cent. For Krasnoiarsk where observations were made in 1835 the value was somewhat different, viz., 0.2666. Therefore I decided to make use of the results of Fedorov by reducing those of 1832-1834 by means of the value 0.2532 and those of 1835 by means of the value 0.2666.

D. Scharnhorst (Zapiski Voenno-Topograficeskago Otdela Upravlenija Generalnago Staba, **37,** 79-84, 1880) gives no particulars about the computations or determinations of the constants of his instruments, but we can presume that the instrument which was used by him during his determinations of 1870-1872 in Turkestan was carefully studied and compared with others but that it was not the case for the instrument used in 1873 and 1874 in Siberia is indicated by the values of H given by Scharnhorst for several points in Siberia where later determinations were made by Fritsche and which differ greatly from the latter. I computed $\log\left(\underline{H}_{\text{Fritsche}} \Big/ \underline{H}_{\text{Scharnhorst}}\right)$ and obtained very consistent values whose mean is 0.1503 ± 0.0023. This mean reduction-factor made it possible to use the remainder of his observations.

Tables XI and XII are constructed similarly to Tables VII and VIII. The corrections are given in units of 10^{-4} C. G. S. and are positive in all the cases when no sign is given. These tables are the result of a new readjustment of the values of $\triangle_{30}$ and $\triangle_{70}$ made after Part I was completed based on new data obtained by the author. These data are mainly determinations made by Mr. R. Abels (Observatory of Ekaterinburg) and Mr. Dombrovskij (Observatory of Irkutsk). The results of Mr. Abels at Berezov and Obdorsk in 1916 were especially valuable for our purposes.

I decided also to change the method of computing the intermediate values, $\triangle_{40}$, $\triangle_{50}$, $\triangle_{60}$, $\triangle_{80}$, $\triangle_{90}$, $\triangle_{00}$. Instead of formulae (3) which correspond to an assumption of simple parabolic variation of H throughout the whole period from 1830 to 1910, I used the following formulae:

$$\left.\begin{array}{l}\triangle_{40}=\triangle_{70}+9/16\ (\triangle_{30}-\triangle_{70});\ \triangle_{50}=\triangle_{70}+4/16\ (\triangle_{30}-\triangle_{70});\\ \triangle_{60}=\triangle_{70}+1/16\ (\triangle_{30}-\triangle_{70});\ \triangle_{80}=\triangle_{70};\ \triangle_{80}=\triangle_{70};\ \triangle_{90}=\\ 26/27\,\triangle_{70};\ \triangle_{00}=19/27\,\triangle_{70}.\end{array}\right\}(8)$$

The latter formulae represent a simple parabolic variation of H during 1830-1870, a constant value of it during 1870-1880, and a cubic parabolic variation during 1880-1910; this corresponds to the increasing rate of diminution of H during the last decades after a period of comparative rest during the seventieth as is clearly shown by the observations at Ekaterinburg and Irkutsk.

Tables XI and XII represent much better the secular variation of H than did the former one: the mean deflection of the observed variations from the calculated is now $= \pm 0.0011$ instead of the former value ± 0.0017. For Ekaterinburg the last column of Table IV which was 0.1724, 0.1737, 0.1744, 0.1748, and 0.1750 becomes now 0.1750, 0.1748, 0.1746, 0.1746, and 0.1744; for 1900, 1909, 1915, and 1918 the former table would give 0.1765, 0.1752, 0.1722, and 0.1712 while the new one gives 0.1759, 0.1748, 0.1738, and 0.1745.

TABLE XI.

Lat. ° \ Long.	60°		65°		70°		75°		80°		85°		90°		95°	
65	...	...	47	26	66	30	84	34	101	38	117	42	132	45	...	47
	...	...	38	26	50	30	62	34	73	38	82	42	94	45	...	47
	...	...	31	25	39	29	47	33	54	37	61	40	67	43	...	45
	...	...	27	18	32	21	37	24	42	27	47	29	51	31	...	33
63	...	...	63	30	79	34	95	38	109	41	123	44	137	46	...	47
	...	...	49	30	59	34	70	38	79	41	88	44	97	46	...	47
	...	...	38	29	44	33	52	37	58	40	64	42	69	44	...	45
	...	...	32	21	37	24	42	27	46	28	49	30	52	32	...	30
61	54	29	75	34	90	38	104	42	117	44	129	46	142	47	...	48
	43	29	57	34	68	38	77	42	85	44	93	46	101	47	...	48
	35	28	44	33	51	37	57	40	62	42	67	44	71	45	...	46
	31	20	36	24	41	27	46	29	49	31	51	32	53	33	...	34
59	65	33	85	38	99	42	111	45	124	47	136	48	147	48	157	48
	51	33	64	38	74	42	82	45	90	47	97	48	104	48	109	48
	41	32	50	37	56	40	61	43	66	45	70	46	73	46	75	46
	35	23	41	27	46	29	49	31	52	33	53	34	54	34	55	34
57	75	38	92	43	107	46	118	48	130	50	141	50	151	50	159	49
	59	38	70	43	80	46	88	48	95	50	101	50	107	50	111	49
	47	37	55	41	61	44	66	46	70	48	73	48	75	48	76	47
	40	27	46	30	50	32	53	34	55	35	56	35	56	35	56	34
55	85	44	99	47	113	50	125	52	136	53	147	53	155	52	161	49
	67	44	76	47	85	50	93	52	100	53	106	53	110	52	112	49
	54	42	59	45	65	48	70	50	74	51	76	51	78	50	77	47
	47	31	50	33	54	35	57	36	58	37	59	37	58	36	56	34
53	94	50	105	52	119	54	132	56	143	56	153	56	159	54	162	50
	75	50	82	52	90	54	99	56	105	56	111	56	113	54	113	50
	61	48	65	50	70	52	75	54	78	54	80	54	80	52	78	48
	53	35	55	36	58	38	61	39	62	39	62	39	61	37	57	35
51	...	58	...	59	...	59	140	60	151	60	159	60	...	...	...	...
	...	58	...	59	...	59	105	60	111	60	116	60	...	...	...	...
	...	56	...	57	...	57	80	58	83	58	85	58	...	...	...	...
	...	41	...	41	...	41	65	42	66	42	66	42	...	...	...	...
49	...	67	...	67	...	66	148	66	159	65	166	64	...	...	...	...
	...	67	...	67	...	66	112	66	118	65	122	64	...	...	...	...
	...	65	...	65	...	64	86	64	88	63	90	62	...	...	...	...
	...	47	...	47	...	46	71	46	71	45	70	45	...	...	...	...
47	...	76	...	75	...	74	...	72	...	70	...	68	...	...	...	...
	...	76	...	75	...	74	...	72	...	70	...	68	...	...	...	...
	...	73	...	72	...	71	...	69	...	67	...	65	...	...	...	...
	...	53	...	53	...	52	...	50	...	49	...	48	...	...	...	...
45	...	85	...	83	...	81	...	78	...	75	...	72	...	...	...	...
	...	85	...	83	...	81	...	78	...	75	...	72	...	...	...	...
	...	82	...	80	...	78	...	75	...	72	...	69	...	...	...	...
	...	60	...	58	...	57	...	55	...	53	...	50	...	...	...	...

TABLE XII.

Long. / Lat.	100°		105°		110°		115°		120°		125°		130°		135°	
65°	...	47	...	47	...	46	...	45	....	44	139	42	134	40	....	......
	...	47	...	47	...	46	...	45	....	44	97	42	93	40	....	......
	...	45	...	45	...	44	...	43	....	42	66	40	63	38	....	......
	...	33	...	33	...	32	...	32	....	31	48	29	46	28	....	......
63	...	47	...	46	...	44	...	41	148	38	144	35	139	32	133	27
	...	47	...	46	...	44	...	41	100	38	96	35	92	32	87	27
	...	45	...	44	...	42	...	39	65	37	62	34	59	31	54	26
	...	37	...	32	...	30	...	29	45	27	42	25	39	22	34	19
61	...	47	...	44	157	41	154	37	151	33	147	29	142	24	137	19
	...	47	...	44	108	41	103	37	99	33	95	29	90	24	85	19
	...	45	...	42	70	39	66	36	62	32	58	28	53	23	48	18
	...	33	...	30	48	29	44	26	40	23	36	20	31	17	26	13
59	163	46	162	42	160	38	157	33	153	28	148	23	....	17	....	11
	112	46	110	42	107	38	103	33	98	28	93	23	....	17	....	11
	75	44	72	40	67	37	64	32	59	27	54	22	....	16	....	11
	53	32	49	29	45	27	41	23	36	20	31	16	....	12	....	8
57	164	46	163	40	160	35	156	29	152	23	146	17	....	10	....	3
	112	46	109	40	105	35	100	29	95	23	90	17	....	10	....	3
	75	44	71	38	66	34	61	28	55	22	49	16	....	10	....	3
	53	32	48	28	43	25	37	20	31	16	25	12	....	7	....	2
55	164	45	162	38	158	32	152	25	146	18	136	10	....	3	....	−4
	112	45	108	38	103	32	97	25	90	18	81	10	....	3	....	−4
	75	43	69	37	63	31	57	24	50	17	42	10	....	3	....	−4
	52	32	46	27	40	22	33	18	26	13	18	7	....	2	....	−3
53	163	44	160	36	154	28	146	20	135	12	....	4	....	−4	....	−11
	110	44	105	36	99	28	91	20	81	12	....	4	....	−4	....	−11
	73	42	67	35	60	27	52	19	43	12	....	4	....	−4	....	−11
	51	31	44	25	36	20	28	14	20	8	....	3	....	−3	....	−8
51	...	43	155	33	149	23	137	14	122	5	....	−3	....	−11	....	−19
	...	43	102	33	94	23	83	14	72	5	....	−3	....	−11	....	−19
	...	41	63	32	55	22	45	13	35	5	....	−3	....	−11	....	−18
	...	30	41	23	31	16	22	10	12	4	....	−2	....	−8	....	−13
49	...	...	147	30	139	18	126	7	108	−2	....	−11	....	−19	....	−28
	...	...	96	30	86	18	74	7	60	−2	....	−11	....	−19	....	−28
	...	...	59	29	48	17	37	7	25	−2	....	−11	....	−18	....	−27
	...	...	37	21	26	13	12	5	5	−1	....	−8	....	−13	....	−20
47	...	...	133	26	125	12	112	0	....	−11	....	−20	....	−29	....	−37
	...	...	90	26	76	12	63	0	....	−11	....	−20	....	−29	....	−37
	...	...	53	25	40	12	28	0	....	−11	....	−19	....	−28	....	−36
	...	...	33	18	19	8	7	0	....	−8	....	−14	....	−20	....	−26
45	...	...	115	22	107	6	95	−7	....	−20	....	−31	....	−39	....	−46
	...	...	74	22	64	6	50	−7	....	−20	....	−31	....	−39	....	−46
	...	...	45	21	31	6	18	−7	....	−19	....	−30	....	−38	....	−44
	...	...	28	15	12	4	0	−5	....	−14	....	−22	....	−27	....	−32

TOMSK, TECHNOLOGICAL INSTITUTE,
December 1918, and March 1919.

RESULTS OF MAGNETIC AND ELECTRIC OBSERVATIONS MADE DURING THE SOLAR ECLIPSE OF JUNE 8, 1918.—*Concluded.*

By L. A. Bauer, H. W. Fisk, and S. J. Mauchly.

Part III.—ATMOSPHERIC-ELECTRIC OBSERVATIONS.—*Concluded.*

Atmospheric-Electric Observations at Lakin, Kansas.—*Concluded.*

Ionic Content.

98. Observations for the determination of the positive-ion content (n_+) of the atmosphere were made with an apparatus similar to that in use on the Carnegie.[1] This apparatus employs a single fiber electroscope of the Einthoven type for noting the

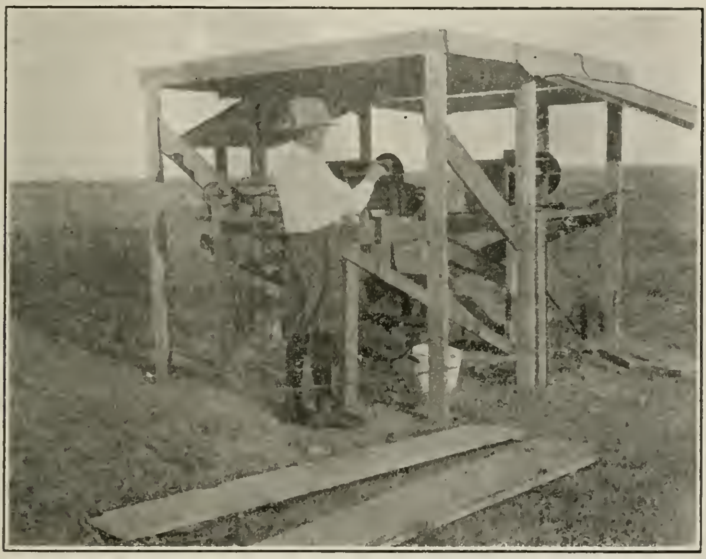

Fig. 23.—Conductivity Apparatus and Shelter at Lakin.

rate of alteration of the potential of the central cylinder during an experiment, and differs from the well-known Ebert ion-counter in causing the ions from the air to be driven to the central system by the action of a suitable charge placed on the insulated outer cylinder. As used at Lakin the electroscope sensitivity was usually from 15 to 20 divisions per volt and the potential of the outer cylinder was maintained at +110 volts. The diameters of the inner and outer cylinders were about 5mm. and 30 mm. respectively,

[1] See W. F. G. Swann, *Terr. Mag.*, Vol. 19, pp. 171-176, 1914.

and the length of each was about 40 cm. The electrical capacity of the entire apparatus was 50.3 cm. As used at Lakin it was always possible to obtain deflections of 10 to 20 scale-divisions in 1 to 2 minutes.

99. The air-flow constant of the clock-driven aspirator is known for sea level, but the normal barometric height at Lakin is between 65 and 70 cm. Owing, however, to the fact that the winds were very variable and nearly always strong enough to cause noticeable fluctuations, sometimes as great as 5 per cent in the time required for the fan to make a given number of revolutions (as indicated by the interval between bell signals), it was not deemed worth while to make á new determination of the air-flow constant under pressure conditions similar to those at Lakin. At Washington, the average rate of air-flow for this apparatus is about 1.3 liters per second, and this value was used for the *approximate* determination of n_+ from the observations made at Lakin,

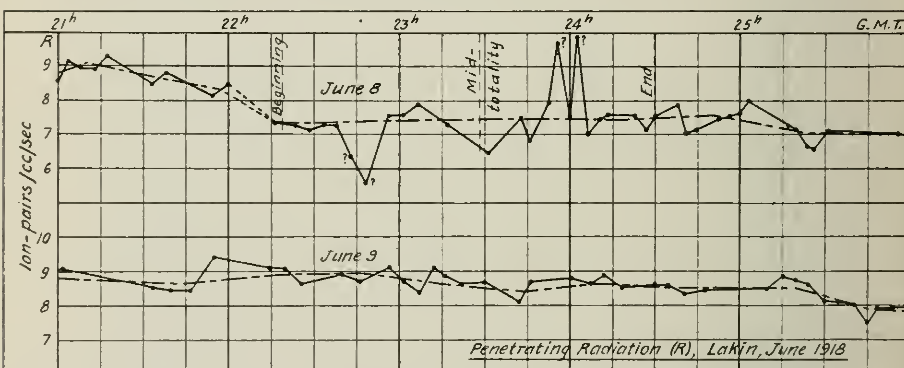

FIG. 24.—Variation of Approximate Ionic-Content at Lakin for Solar Eclipse, June 8, 1918, and Mean Curve.

although it no doubt is too small, and consequently the computed results for n_+ are *too large*. It may be noted in passing that under the conditions described all ions having a velocity greater than about 0.07 cm. per second in unit field will be accounted for in the measurements.

100. Control observations were made on the afternoons of June 5, 6, 9, and 12. A curve embodying the means of the results of these observations is shown in Fig. 24. The curve of June 8 for n_+, shown in Fig. 24, shows a gradual increase in the ionic content during the first half of the eclipse similar to what was regularly observed shortly before sunset at this station. From $23^h\ 07^m$

to $23^h\ 49^m$ (G. M. T.) no reliable observations for ionic content were obtained, owing to the development of leak and temperature troubles with the ion-counter electroscope. At the time this trouble developed it was decided to concentrate on the observations for penetrating radiation which were being made by the same observer. As soon as sufficient time could be spared from these latter observations to remedy the difficulty, the ionic-content observations were resumed and continued throughout the afternoon. The curve shows that from about $23^h\ 50^m$ to the end of the eclipse there was a rather large and rapid diminution in n_+ which was later followed by the normal evening increase mentioned above.

Penetrating Radiation.

101. For the measurement of the penetrating radiation the rate of ionization within a cylindrical copper vessel of 21.3 liters capacity was determined by observations on a single-fiber electroscope after the vessel had been thoroughly cleaned and sealed. The arrangement employed was similar to that used aboard the *Carnegie* and described on page 389, Vol. III, *Researches of the Department of Terrestrial Magnetism.* The time occupied by a single experiment was of the order of 3 to 5 minutes and frequent determinations of sensitivity were made in order to avoid instrumental errors due to the large variations in temperature associated with the progress of the eclipse, as also during the 24 hours of the diurnal-variation experiments to be described later. Leak effects were entirely avoided, as indicated in the reference given above, by choosing the scale limits between which the fiber traveled to correspond to potentials of opposite sign which differed by several tenths of a volt and which were symmetrical about the position occupied by the fiber when it was connected to earth. Repeated observations during the regular course of the work showed that the lengths of time spent by the fiber in traversing the two halves of its course did not differ by an observable amount.

102. It was not possible to set up the penetrating-radiation apparatus until the afternoon of June 7 when several test observations were made. The observations were continued throughout the afternoon of June 8 and are represented graphically in the upper part of Fig. 25. After observing for several hours it was found desirable at $22^h\ 12^m$ (G. M. T.) to readjust several parts of the apparatus. Inasmuch as there had been no opportunity prior to this time to determine the constants of the apparatus,

the values obtained before the readjustment are not strictly comparable with those obtained thereafter and on succeeding days. They do, however, serve to show whatever variation the ionization in the chamber was undergoing prior to the time of adjustment.

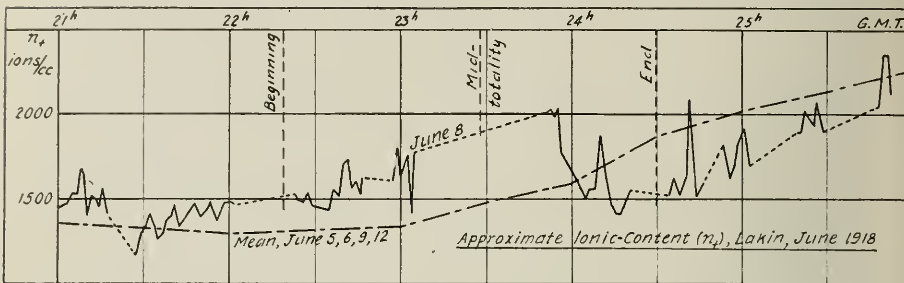

Fig. 25.—Variation of Penetrating Radiation at Lakin for Solar Eclipse, June 8, 1918, and for June 9, 1918.

103. Table 33 shows the individual results of the penetrating-radiation observations together with mean values obtained by grouping the results of approximately 30-minute intervals. In forming these means, 4 values, designated by asterisks (*), have not been included since it appears probable, from the observational data, that errors of time-reading or of recording may be responsible for their characteristics. The mean values from Table 33 are shown graphically by the broken line in Fig. 25 in connection with the detailed curve for June 8. On the afternoon of June 9 observations were carried out similar to those on June 8 with no appreciable difference except that the average rate of ionizations was found to be about 10 per cent greater than on the preceding day. These results have not been tabulated but they are shown graphically in the lower part of Fig. 25, together with a curve for the 30-minute means, formed as for June 8. When the material for June 8 and 9 is viewed as a whole there seems to be no evidence to indicate that the rate of ionization in the apparatus underwent any appreciable change during the progress of the eclipse. Or, in other words, such part, if any, of the penetrating radiation which was due to the Sun did not form a large enough proportion of the total effect due to all causes, that any change caused by its temporary removal could be observed with certainty by the method employed. This is in accord with the findings of de Broglie[2] who made similar observations at Paris during the solar eclipse of April 17, 1912.

[2]de Broglie, *Comptes Rendus*, June 10, 1912, p. 1652.

Tabulation of Results for June 8, 1918.

104. Values of potential gradient, of positive conductivity (λ_+) and of negative conductivity (λ_-), and rate of ionization (R) within a closed vessel, all as observed at Lakin on June 8, 1918, are given in Tables 31, 32, and 33.

TABLE 31.—*Potential-gradient values (X) observed at Lakin, Kansas, June 8, 1918.*

G.M.T.	X	G.M.T.	X	G.M.T.	X	G.M.T.	X
h m	v/m	h m	v/m	h m	v/m	h m	v/m
20 00	84.6	21 32	82.8	23 00	58.2	24 34	53.9
20 02	72.0	21 34	66.7	23 02	67.2	24 36	59.5
20 04	63.2	21 36	55.6	23 04	67.4	24 38	52.7
20 06	72.0	21 38	61.8	23 06	55.0	24 40	53.9
20 08	89.4	21 40	61.3	23 08	53.4	24 44	46.4
20 10	66.2	21 42	55.6	23 10	64.3	24 46	49.7
20 12	72.0	21 44	55.6	23 14	52.8	24 48	58.6
20 14	82.8	21 46	62.4	23 16	54.0	24 50	54.5
20 16	58.2	21 48	75.6	23 18	64.7	24 52	55.8
20 19	59.2	21 50	74.4	23 20	72.2	24 55	54.0
20 22	74.5	21 52	70.9	23 22	59.6	24 56	50.9
20 24	61.2	21 54	58.2	23 24	57.0	24 58	52.7
20 26	94.2	21 56	70.2	23 27.5	55.8	01 00	50.4
20 28	65.4	21 58	62.5	23 29	50.8	01 02	50.2
20 30	55.8	22 00	69.4	23 30.5	49.8	01 04	54.0
20 33	75.6	22 02	73.2	23 33	49.4	01 07	52.1
20 38	77.8	22 04	82.8	23 34	46.6	01 12	47.9
20 40	74.4	22 06	61.2	23 36	48.6	01 14	45.5
20 42	66.6	22 08	76.2	23 38	48.5	01 16	44.3
20 44	76.1	22 10	58.2	23 42	48.5	01 18	52.3
20 46	62.4	22 13	70.8	23 44	48.5	01 20	48.5
20 48	64.3	22 16	69.6	33 46.5	49.6	01 22	48.0
20 50	58.2	22 18	61.1	23 50	52.8	01 24	44.3
20 52	72.0	22 20	61.2	23 52	50.8	01 26	43.7
20 54	58.8	22 22	65.6	23 53	51.6	01 28	40.1
20 56	61.8	22 24	64.2	23 54	53.4	01 30	40.1
20 58	62.5	22 26	53.0	23 55	53.4	01 32	44.3
21 00	59.4	22 28	55.7	23 59	51.7	01 35	42.5
21 02	54.0	22 30	58.1	24 00.5	48.6	01 36	43.2
21 04	56.0	22 32	62.6	24 03	49.9	01 38	46.0
21 06	60.6	22 34	58.2	24 04.5	55.8	01 40	41.3
21 08	73.8	22 36	57.0	24 06	50.6	01 42	41.9
21 10	60.0	22 38	54.0	24 08	51.5	01 44	41.3
21 12	61.7	22 40	78.7	24 10	67.7	01 46	41.5
21 14	57.0	22 42	72.0	24 12	56.6	01 48	38.4
21 16	82.1	22 44	52.8	24 14	50.6	01 50	41.5
21 18	54.0	22 46	56.0	24 17	56.3	01 52	40.7
21 21	61.2	22 48	72.7	24 19	49.3	01 54	41.0
21 22	55.2	22 50	55.0	24 22	59.3	01 56	41.3
21 25	76.8	22 52	68.2	24 25	51.8	01 58	41.5
21 26	77.8	22 54	83.6	24 27	62.9	02 00	40.7
21 28	55.7	22 56	59.2	24 30	52.7	02 02	41.3
21 30	68.2	22 58	63.4	24 32	58.1		

TABLE 32.—*Values of positive conductivity* (λ_+) *and of negative conductivity* (λ_-) *observed at Lakin, Kansas, June 8, 1918.*

G.M.T.	E.S.U.×10⁻⁴ λ_+	E.S.U.×10⁻⁴ λ_-	G.M.T.	E.S.U.×10⁻⁴ λ_+	E.S.U.×10⁻⁴ λ_-	G.M.T.	E.S.U.×10⁻⁴ λ_+	E.S.U.×10⁻⁴ λ_-	G.M.T.	E.S.U.×10⁻⁴ λ_+	E.S.U.×10⁻⁴ λ_-
h m			h m			h m			h m		
20 14.4	3.45	....	21 49.0	....	3.52	23 14.7	4.25	....	24 30.2	....	3.52
15.4	....	2.67	50.2	3.52	....	15.7	....	3.52	31.4	3.86	....
16.7	3.15	....	51.2	....	3.34	17.0	4.02	....	32.4	....	3.58
17.7	....	3.28	52.4	4.08	....	18.0	....	3.15	33.7	4.41	....
19.0	3.45	....	53.4	....	3.52	19.2	3.72	....	34.7	....	3.52
20.0	....	3.07	54.7	3.79	....	20.2	....	3.15	36.0	4.25	....
21.2	3.38	....	55.7	....	3.34	21.4	3.65	....	37.0	....	3.81
22.2	....	3.28	57.0	3.72	....	22.4	....	3.66	38.2	4.73	....
23.4	3.38	....	58.0	....	3.15	23.7	4.73	....	39.2	....	3.52
24.4	....	3.15	59.2	3.52	....	24.7	....	4.19	40.4	4.61	....
25.7	3.38	....	22 00.2	....	3.34	26.0	5.22	....	41.4	....	3.52
26.7	....	3.22	13.2	3.83	....	27.0	....	4.11	50.2	3.99	....
37.2	3.92	....	14.2	....	3.01	28.2	5.18	....	51.2	....	3.58
38.2	....	3.01	15.4	4.08	....	29.2	....	4.70	52.4	4.70	....
39.4	3.45	....	16.4	....	3.15	30.4	4.77	....	53.4	....	3.58
40.4	....	2.88	17.7	3.68	....	31.4	....	4.34	54.7	5.34	....
41.7	3.45	....	18.7	....	3.22	32.7	4.22	....	55.7	....	4.40
42.7	....	3.07	20.0	3.72	....	33.7	....	4.05	57.0	5.22	....
44.0	3.49	....	21.0	....	3.34	35.0	4.68	....	58.0	....	3.98
45.0	....	3.31	22.2	3.72	....	36.0	....	4.11	59.2	4.61	....
46.2	3.38	....	23.2	....	3.28	37.2	4.65	....	25 00.2	....	3.81
47.3	....	3.25	24.4	3.49	....	38.2	....	4.26	01.4	4.86	....
49.0	3.62	....	25.4	....	3.28	39.4	5.06	....	02.4	....	3.81
49.7	....	3.22	33.2	3.72	....	40.4	....	4.62	16.4	4.49	....
21 03.7	3.22	....	34.2	....	3.28	41.7	5.34	....	17.4	....	3.66
04.7	....	3.39	35.4	3.79	....	42.7	....	4.85	18.7	4.81	....
06.0	4.13	....	36.4	....	3.22	44.0	5.02	....	19.7	....	3.81
07.0	....	3.42	37.7	3.79	....	45.0	....	3.81	21.0	4.54	....
08.2	4.13	....	38.8	....	3.34	46.2	4.97	....	22.0	....	3.34
09.2	....	3.31	40.0	3.95	....	47.2	....	4.48	23.2	4.54	....
10.4	3.56	....	41.2	....	3.28	48.4	4.97	....	24.2	....	3.34
11.4	....	3.15	42.2	3.95	....	49.4	....	4.19	25.4	4.54	....
12.7	3.61	....	43.4	....	2.94	50.7	5.41	....	26.4	....	3.52
13.7	....	3.01	44.4	3.95	....	51.7	....	4.34	27.7	4.54	....
15.0	3.99	....	45.7	....	3.34	53.0	5.41	....	28.7	....	3.90
16.0	....	3.22	52.2	3.72	....	24 04.2	4.02	....	47.0	4.93	....
26.4	3.28	....	55.2	....	3.34	07.2	....	3.15	48.0	....	4.40
27.5	....	2.61	54.4	3.72	....	08.0	3.95	....	49.2	4.45	....
28.7	3.31	....	57.4	....	3.42	09.4	....	3.81	50.2	....	4.48
29.7	....	2.67	58.0	4.18	....	10.2	4.38	....	51.7	5.18	....
31.0	3.49	....	59.7	....	3.58	11.7	....	3.73	52.4	....	4.56
32.0	....	3.15	23 00.2	3.72	....	12.4	4.02	....	54.0	5.41	....
33.2	3.49	....	02.0	....	3.76	14.0	....	3.46	54.7	....	4.77
34.2	....	3.01	02.4	4.18	....	14.7	3.95	....	56.2	5.18	....
35.4	3.38	....	04.6	....	?	16.2	....	3.22	57.0	....	4.62
36.4	....	3.07	10.2	4.29	....	17.0	3.95	....	58.4	5.18	....
37.7	3.72	....	11.2	....	3.52	18.4	....	3.07	59.2	....	4.40
38.7	....	2.67	12.4	4.34	....	19.2	3.83	....	....	....	....
48.0	3.28	....	13.4	....	3.42	29.2	3.86	....	....	....	....

TABLE 33.—*Rate of ionization (R) in ion-pairs per cubic centimeter per second within a closed vessel as observed at Lakin, Kansas, June 8, 1918.*

G.M.T.	*R*	Mean Time of Group	No. of Obs.	*R*	G.M.T.	*R*	Mean Time of Group	No. of Obs.	*R*
h m		h m			h m		h m		
19 40	8.4				42	7.5			
45	8.3	19 48	3	8.4	45	6.8			
58	8.5				52	8.0	23 50	4	7.5
20 23	7.5	20 27	2	8.1	55	9.7*			
31	8.7				24 00	7.6			
44	8.3				2	9.9*			
49	8.8	20 51	4	8.5	06	7.0			
54	8.5				10	7.5			
59	8.5				13	7.6	24 18	6	7.4
21 03	9.2				23	7.6			
08	8.9				27	7.2			
13	8.9	21 10	4	9.1	30	7.6			
17	9.3				38	7.9			
33	8.5				41	7.1			
38	8.8	21 46	4	8.5	46	7.2			
54	8.2				53	7.5	24 51	7	7.6
22 00	8.5				57	7.6			
16	7.4				25 00	7.7			
23	7.3				03	8.0			
28	7.2	22 27	5	7.3	17	7.3			
33	7.3				20	7.2			
38	7.3				24	6.7	25 24	5	7.0
43	6.4*				26	6.6			
48	6.8*				31	7.2			
56	7.6				56	7.0	25 59	2	7.0
23 01	7.6				26 01	6.9			
06	7.9	23 10	5	7.4					
17	7.3								
31	6.5								

* These values not included in forming the means of last columns; see section 103.

Meteorological Conditions during Totality.

105. The time during and near totality was marked by rather light gusts of wind of varying intensity and direction. Recording instruments located in a nearby shelter showed, during the first half of the eclipse, a drop of more than 5° C. in temperature and an increase in relative humidity from 55 per cent to 65 per cent. Comparison observations made later indicate that the changes at the observing stations were somewhat larger than those recorded in the shelter. The reference to clouds, in paragraph 90, should be qualified by a statement that light cirrus clouds developed several times during the afternoon. Very few clouds were in evidence, however, near the time of totality except the low cumuli noted in paragraph 90.

Diurnal-Variation Observations.

106. Mention has been made in the foregoing of the control observations made on June 5, 6, 9, and 12 for potential gradient, conductivity, and ionic content. In addition to serving as control observations, however, the results of such observations have a value quite independent of any association with the eclipse, by affording data, even though limited, for a region concerning which no published atmospheric-electric data are available. Partly to increase the amount of atmospheric-electric data in general, and partly because it seems natural to consider the passage of the moon's shadow during an eclipse as a miniature night, the observations beginning on the afternoon of June 12 were continued throughout 24 consecutive hours.

107. The general plan was to make successive observations for λ_+, λ_-, n_+, and R, for a period of about 20 minutes out of each hour and to make potential-gradient observations, at intervals of about 5 minutes, as nearly as possible without interruption. We have then for the various hours of the day mean values of λ_+, λ_-, n_+, and R, respectively, each mean based on all the observations of its kind made during a given 20-minute interval. Fig. 26 shows these mean values plotted against the corresponding mean times. The potential-gradient results, however, are individually represented in the graph at the bottom of the figure. The air-earth current-density shown in the upper part of the figure was computed from the 20-minute means of the total conductivity and the mean potential-gradient for the corresponding 20-minute periods. Dotted portions of curves indicate lack of data for the parts in question.

108. The data set forth in Fig. 26 show a very large diurnal-variation for all the elements under observation except the ionization in a closed vessel. The close agreement between late afternoon results on June 5, 6, 8, 9, and 12, would indicate that Fig. 26 gives a fairly good representation of the diurnal variation for the station and season in question. It should be noted that the station was located in a region devoted almost exclusively to the growing of alfalfa and that it was located in the middle of a large, irrigated, alfalfa field. The diurnal ranges of both temperature and relative humidity were rather large, the former being about 20° C., and the latter extending from 30 per cent to 75 per cent. Although observations for R could not be made as regularly during the night hours as was done for the other elements, enough data

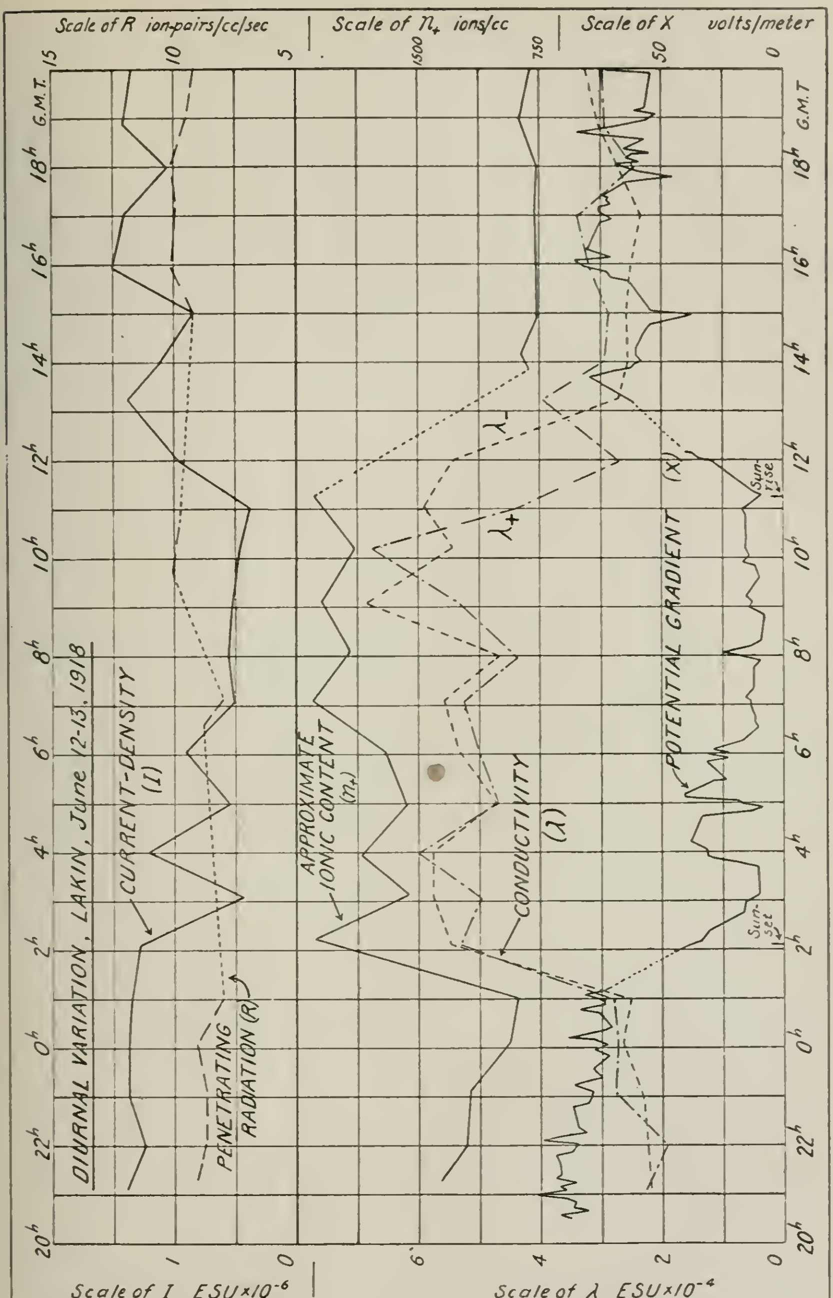

FIG. 26.—Diurnal Variation of Atmospheric-Electric Elements at Lakin for June 12 to 13, 1918.

were secured to make it appear that any diurnal variation of the rate of ionization in a closed vessel, at the given station and time, was small and certainly did not exceed 20 per cent of its mean value.

Atmospheric-Electric Observations at Washington, D. C.

109. Continuous photographic records of the positive conductivity and of the potential-gradient were obtained on June 8 at the atmospheric-electric observatory of the Department of Terrestrial Magnetism, at Washington, D. C. The maximum obscuration at this station was 74 per cent and excellent traces were recorded. Neither trace shows effects which could with any degree of certainty be ascribed to the influence of the eclipse.

Chief Conclusions for Part III (Electric Observations).

110. At the Lakin station, located in the belt of totality at an elevation of 900 meters, on an irrigated, grassy plain, far from either sea or mountains, the observations[1] during the total solar eclipse of June 8, 1918, indicated:

a. A decrease of about 20 per cent in the value of the potential-gradient at the time of totality and continuing for a period of about 20 minutes thereafter.

b. The short-period fluctuations which usually characterize the potential-gradient and which were very marked both before and after the eclipse were almost totally absent during the period of minimum potential-gradient, namely during totality and the 20 minutes immediately following.

c. The unipolar conductivities, λ_+ *and* λ_-*, each showed an increase, of the order of 20 per cent, during a period beginning several minutes before totality and continuing until about 30 minutes after totality. Inasmuch as* λ_+ *and* λ_- *were similarly affected, the remark concerning them applies also to the total conductivity.*

d. The air-earth current-density, as computed from total-conductivity and potential-gradient data, showed a rapid increase for about 10 minutes before totality followed by an equally rapid and pronounced decrease for about 10 minutes after totality. Neither of these movements, however, is in marked contrast to the course followed by this element throughout the afternoon.

e. The ionic content of positive sign, n_+*, appears to have passed*

[1] Corrigenda to atmospheric-electricity installment appearing in March 1919 issue: Page 26, line 18, read *Table 32* instead of *Table 31;* page 26, line 8, paragraph 97, read *Elster* instead of *Geitel.*

through a maximum simultaneously with λ_+, but lack of observations during the middle part of the eclipse prevents a positive statement on this point.

f. The ionization in a closed vessel, due to the penetrating radiation, apparently was unaffected by the passage of the eclipse-shadow.

g. Observations throughout 24 consecutive hours showed a large diurnal-variation for all the elements under observation, except the ionization in a closed vessel. They also showed for all elements a strong similarity between night conditions and those prevailing on June 8 during and shortly after totality.

DEPARTMENT OF TERRESTRIAL MAGNETISM,
CARNEGIE INSTITUTION OF WASHINGTON.

RESULTS OF MAGNETIC AND ELECTRIC OBSERVATIONS MADE DURING THE SOLAR ECLIPSE OF JUNE 8, 1918.

BY L. A. BAUER, H. W. FISK, AND S. J. MAUCHLY.

CONTENTS.

ILLUSTRATIONS

WOLFER PROVISIONAL SUN-SPOT NUMBERS FOR JULY TO DECEMBER, 1918[1].

COMMUNICATED BY G. VAN DIJK.

Date	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	99	122	62	68	56	39
2	101	....	47	84	52	41
3	115	125	41	85	50	....
4	....	130	33	71	27?	41
5	142	....	33	61	40	40
6	141	99	38	70	28	....
7	134	75	55	71	29	44
8	132	81	....	....	33	....
9	105	49	70	64	....	....
10	....	61	79	....	28	26
11	101	62	....	....	31	29
12	87	103	....	75	....	43
13	58	121	73	....	38	....
14	67	111	92	....	62	40
15	94	109	80	....	80	....
16	84	142	66	58	98	16
17	67	128	76	....	....	48
18	60	130	76	....	....	59
19	72	78	59	....	....	....
20	67	113	....	104	163	52
21	92	104	71	149	187	68
22	115	109	110	125	127	....
23	121	119	....	127	....	....
24	145	73	....	....	80	....
25	138	85	87	....	107	113
26	141	77	74	....	53	115
27	126	73	85	101	....	116
28	....	88	140	80	....	80
29	124	62	145	70	....	....
30	110	38	....	....	60	32?
31	91	62		....		....
Means...	104.6	94.1	73.5	86.1	68.0	54.8

Mean for 1918; 77.6

[1]Derived from the *Meteorologische Zeitschrift;* for previous tables, see *Terr. Mag.*, vol. 23, p. 136, and vol. 24, p. 43.

LETTERS TO EDITOR

ADDITIONAL MAGNETIC OBSERVATIONS OBTAINED BY THE *CINCO DE OUTUBRO* OFF THE COAST OF PORTUGAL.

Besides the data given in the Reports[1] of the Missão Hidrográfica da Costa de Portugal the following additional values, all referred to the year 1915, were determined:

Latitude 39° 52′ N, longitude 9° 18′ W: Declination 16° 15′ W; inclination 58° 26′ N; total intensity 0.4396 C. G. S.; horizontal intensity 0.2302 C. G. S.

Latitude 37° 01′ N, longitude 7° 27′ W: Declination 15° 07′ W; inclination 55° 16′ N; total intensity 0.4290 C. G. S.; horizontal intensity 0.2444 C. G. S.

Lisbon, March 20, 1919. RAÚL MÁRIO DE SERRA GUEDES.

[1]Ministério da Marinha, Missão Hidrográfica da Costa de Portugal. Relatório dos trabalhos executados durante a campanha do aviso *Cinco de Outubro*, em 1913, e 1914, Lisboa, 1915, 1918.

NOTE ON A POSSIBLE EXPLANATION OF THE "ELECTRIC TIDE" OBSERVED AT JERSEY[1].

On page 34 of the March 1919, issue of this Journal Father Dechevrens says "If the electromotive force is to be sought in the movement of the waters of the ocean, its greatest variation will accompany the greatest movements which naturally precede by some time the slack water of low and high tides." This, of course, looks to the electromagnetic induction-effects produced by the tidal waters in cutting across the Earth's magnetic field as the explanation of the phenomenon under discussion. It is the purpose of this note to suggest briefly an entirely different line of inquiry which also leads to a possible explanation of the observed effects.

Several interesting articles by Mr. E. G. Bilham[2] have recently come to the writer's attention. In the first of the articles cited, it is shown that the water level in an experimental well at Kew Observatory responds to variations in the local barometric pressure. In the other two papers the well was shown to follow the fortnightly oscillation of the mean level of the Thames, and well-marked solar and lunar diurnal-variations were found for each of 24 consecutive months. The short-period tides of the solar and lunar series were found to take the form of double oscillations with two maxima and two minima during 24 hours. The "spring tides" occur in the well 3.3 days after they occur in the river and the lunar fortnightly tides 5.1 days later than in the river. It is assumed that these are the times required for the respective waves to travel through the subsoil from the river to the well.

Now in the March 1918, number of this Journal, pp. 37 and 38, we find that for the Jersey measurements the *galvanized* water-pipe system of the St. Louis Observatory was connected through a sensitive galvanometer to the gas-

[1]See *Terr. Mag.*, Vol. 23, pp. 37-39, 1918; *Terr. Mag.*, Vol. 23, pp. 145-147, 1918; *Comptes Rendus*, Vol. 167, pp. 552-555, 1918; *Terr. Mag.*, Vol. 24, pp. 33-38, 1919.

[2]See *Proc. Roy. Soc.*, Vol. 94, pp. 165-181, 1918; *Proc. Roy. Soc.*, Vol. 94, pp. 476-478, 1918; *Q. J. R. Meteor. Soc.*, Vol. 44, pp. 171-189, 1918.

pipe system of the city of St. Helier; also that the gas-pipe system was always positive to the water-pipe system, which is what one would expect in case the gas pipes were not galvanized. The Observatory grounds are situated on a hill overlooking the city and about 50 meters above it.

Viewing these circumstances in the light of Mr. Bilham's results, it does not seem improbable that a direct effect of the tides in the harbor should be registered by the galvanometer on account of the unequal access of the underground tidal seepage to the low-lying gas-pipe system and the much more elevated water-pipe system. From the well-known behavior of concentration cells, periodic fluctuations of electromotive force would be a necessary consequence of the difference in accessibility of the two systems to a periodical tidal seepage. It is also possible that the periodic immersion of *different* parts of the lower system is partially responsible for periodic variations in the observed electromotive force.

Without detailed knowledge of the topography and geological structure at the place where the observations were made, it is impossible to say how large a part of the observed effect could be accounted for in this way. The possible magnitude of such an effect could be investigated experimentally. It would also be desirable to make in Jersey water-level observations similar to those at Kew at some point within the lower region occupied by the gas-pipe system. Electrolytic effects of the nature anticipated do not, of course, exclude the induction effects suggested by Father Dechevrens.

Washington, D. C., May 31, 1919. S. J. MAUCHLY.

NOTES

6. *Principal Magnetic Storms at Cheltenham Magnetic Observatory, January to March*, 1919.[1]

Greenwich Mean Time		Range		
Beginning	Ending	Declination	Hor'l Int.	Vert'l Int.
h m	h	′	γ	γ
Jan. 3, 17 12	Jan 6, 2 ..	46.3	226	114
Feb. 27, 19 27	Mar. 1, 20 ..	39.2	148	207
Mar. 19, 19 ..	Mar.23, 9 ..	49.8	128	264

7. *Future Work of the "Carnegie"*. After a thorough overhauling and the substitution of the producer-gas engine by a gasoline engine, it is expected that the *Carnegie* will resume her ocean work in September 1919, after having been out of commission at Washington for about one year. Her next cruise (No. VI) will be mainly in the South Atlantic, Indian, and Pacific Oceans, and will cover a period of two to three years. The scientific personnel will consist as follows: *J. P. Ault*, in command; *H. F. Johnston*, observer and second in command; *R. Pemberton*,

[1] Communicated by *E. Lester Jones*, Superintendent U. S. Coast and Geodetic Survey; *Geo. Hartnell*, Observer-in-charge. Lat., 38°44.0′ N; long., 76°50.5′ W, or 5h 07.4m W of Greenwich.

surgeon; *A. Thomson*, *H. R. Grummann*, and *R. R. Mills*, observers. The ports of call in 1919 will be: Dakar, Senegal, in October; Rio de Janeiro, in October; St. Helena, in December.

8. *A new Antarctic Expedition.* We learn from *Nature* of a new expedition to the Antarctic announced to sail in June, 1920. It will be known as the British Imperial Antarctic Expedition, and will be under the leadership of Mr. J. L. Cope, who accompanied the Ross Sea party of the recent Imperial Antarctic Expedition, 1914–17, as surgeon and naturalist. It is understood that the plans include a base at New Harbour, in Victoria Land, and a wintering party in the middle of the Ross Barrier, mainly with a view to meteorological and magnetical observations. The ship to be used, the *Terra Nova*, is a vessel of proved capacity for Antarctic work. The expedition is expected to last for six years, during which time communication with civilization will be kept up by wireless telegraphy.

9. *Personalia.* We regret to record the deaths of *William Watson*, F. R. S., the well-known physicist and magnetician, on March 3, 1919, at the age of fifty years, of *Henry Wilde*, founder of the Halley lecture-ship, on April 3, 1919, at the age of eighty-six years, of *Walter Gould Davis*, formerly director of the Meteorological Bureau of Argentina, on April 30, 1919, at the age of sixty-eight years, and of *Walter Sidgreaves*, S. J., for many years director of the Stonyhurst College Observatory, on June 12, 1919, at the age of eighty-one years. *H. F. Johnston*, who during the war was commissioned a lieutenant in the Royal Naval Reserve and assigned to the Admiralty Compass Observatory at Slough, England, reëntered the employ of the Department of Terrestrial Magnetism in April, 1919. After assisting Dr. Bauer in the eclipse magnetic and electric observations at Cape Palmas, Liberia, he will resume duty aboard the *Carnegie* (see Note 7). *E. Kidson*, Captain R. E., was made an Officer of the Military Division of the Order of the British Empire for work in connection with the military operations in Salonika; when demobilized, he will take charge of the observatory of the Department of Terrestrial Magnetism at Watheroo, Australia.

10. *Corrigenda.* Through an unfortunate oversight in proof reading the erroneous spelling *Deschevrens* was used in the September 1918 and in the March 1919 issues in connection with the articles by the Rev. Marc Dechevrens, S. J. Vol. 23, 1918, p. 136: The mean sun-spot number for February 1918 should read 63.4 instead of 83.4. Vol. 24, 1919, p. 43: The sun-spot number for April 11, 1918, should read 85 instead of 35. Vol. 24, 1919, p. 26: Read Table 32 instead of Table 31 in line 18; read Elster instead of Geitel in line 8 of paragraph 97.

RECENT PUBLICATIONS

A. Terrestrial and Cosmical Magnetism.

AGINCOURT AND MEANOOK OBSERVATORIES. Magnetic observations, September–December, 1918. Toronto, J. R. Astr. Soc. Can., v. 12, 1918 (520–521); v. 13, 1919 (23–24), (71–72), (152–153).

AGINCOURT AND MEANOOK OBSERVATORIES. Magnetic disturbances during January, 1919. Toronto, J. R. Astr. Soc. Can., v. 13, No. 4, April, 1919 (201).

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GEOPHYSICISTS AT THE UCCLE OBSERVATORY, JULY 26, 1919.
(Left to right: Bauer, Reina, Tanakadate, Hermant, Chree.)

Terrestrial Magnetism
and
Atmospheric Electricity

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TERRESTRIAL MAGNETISM AND ELECTRICITY AT THE BRUSSELS MEETINGS, JULY 18-28, 1919.

BY LOUIS A. BAUER.

During the meetings at Brussels, July 18-28, 1919, of the International Research Council, there were established under the auspices of the Council, various new international unions of astronomy, geophysics, mathematics, physics, chemistry, biology, and scientific radio-telegraphy. The union of chief interest to readers of this journal is "The International Geodetic and Geophysical Union," consisting of the following sections and officers:

	Section	*President*	*Vice-President*	*Secretary and Director of Central Bureau*
A.	Geodesy	William Bowie (U. S. Coast and Geodetic Survey)	Vincenzo Reina (Italian Geodetic Commission)	Lt. Col. G. Perrier (Army Geographic Service, Paris)
B.	Seismology	Organization deferred.		
C.	Meteorology	Sir Napier Shaw (British Meteorological Office)	A. Angot (French Meteorological Bureau)	C. F. Marvin (U. S. Weather Bureau)
D.	Terrestrial Magnetism and Electricity	A. Tanakadate (University of Tokyo)	Charles Chree (Kew Observatory)	Louis A. Bauer (Carnegie Department of Terrestrial Magnetism)
E.	Physical Oceanography	....	H. Lamb (University of Manchester)	G. P. Magrini (Hydrographic Office, Venice)
F.	Vulcanology	A. Riccò[1] (Observatory Etna, Sicily)	H. S. Washington (Carnegie Geophysical Laboratory)	A. Malladra (Vesuvius Observatory)

[1] Since appointment, Prof. Riccò has unfortunately died.

The *objects of the International Geodetic and Geophysical Union* are stated in the official, or French, version as follows:

1. To promote the study of problems concerned with the figure and physics of the Earth.
2. To initiate and co-ordinate researches which depend upon international co-operation and to provide for their scientific discussion and publication.
3. To facilitate special researches, such as the comparison of instruments used in different countries.

Since there were represented at Brussels this time only the countries of the Allies, it was concluded to defer complete organization of the sections until the entrance into the Union of other countries to be invited by the International Research Council. In the case of Section B (Seismology), since the agreement among nations belonging to the International Seismological Association, formed before the war, does not expire until April 1, 1920, it was necessary to postpone any organization, whatsoever, of the section. However, as the central office of the Association is at Strasburg, it will likely continue there when the Section of Seismology is organized.

The *Executive Committees of the Sections* were for the present limited to the president, vice-president, and secretary, excepting in the case of *E* (Physical Oceanography) where Sir Charles Close (British Ordnance Survey) and Mr. G. W. Littlehales (U. S. Hydrographic Office) were made additional members of the executive committee of that section.

The *officers of the International Geodetic and Geophysical Union* are: President, M. Charles Lallemand (Director, Levelling Service, France); General Secretary, Colonel H. G. Lyons (Army Meteorological Service, Great Britain). These two officers, with the addition of the presidents of the Sections, who are the vice-presidents of the Union, constitute the *Executive Committee of the Union.*

According to the method of organization and the interpretation put upon the office of secretary, it is expected that the affairs of the unions and sections, between the triennial meetings of the General Assembly, will be largely conducted by the respective secretaries, as is the case also with regard to the general secretaryship of the International Research Council, to which Professor Arthur Schuster was re-elected. Thus, according to the French version of the statutes of the Union, which were made to

conform to those of the International Research Council, the secretary's duties are defined as follows:

> The Secretary of a Section shall act as Director of its Central Bureau. He shall be responsible for the conduct of correspondence, the management of the resources, the custody of the documents, the preparation and issue of publications and such other matters as the General Assembly may refer to him.

Organization of Work. In section A (Geodesy), which is to take the place of the former International Geodetic Association, it was decided to defer the appointment of committees and the organization of international research work in geodesy until the next general meeting (1922) of the Union, or until some previous special meeting. At a joint meeting of geophysicists and astronomers it was finally decided to leave to the International Astronomical Union the future international variation-of-latitude observations.

Section C (Meteorology) it was generally agreed, by confining its work to research and fundamental problems in meteorology, could usefully and effectively supplement the functions and work of the pre-war International Meteorological Committee. The latter, as it consisted of official weather-bureau directors, necessarily had to concern itself primarily with administrative and official meteorological questions. In the unavoidable absence of the elected president, Sir Napier Shaw, no organization of work was attempted except the passing of the two resolutions in the morning of July 24 to the following effect:

> The hope is expressed
>
> *a.* That there be appointed a Joint Committee of the International Astronomical Union and of the Section of Meteorology of the International Geodetic and Geophysical Union for investigational work on solar radiation;
>
> *b.* That international work in atmospheric electricity, as far as possible, be placed under the direction of a committee nominated partly by the Section of Terrestrial Magnetism and Electricity and partly by the Section of Meteorology.

The work of section D (Terrestrial Magnetism and Electricty) could be more completely organized than that of the other sections, as it happened that there were present at Brussels six members of the pre-war Magnetic Commission of the International Meteorological Committee, viz.: Angot (France), Bauer (United States), Chree (England), Palazzo (Italy), Schuster (England) and Tanakadate (Japan). At preliminary, informal meetings of the delegates

from the various allied countries it developed that there was practically unanimity in the proposal of a section by itself which should be concerned specifically with the subjects of terrestrial magnetism and terrestrial electricity (atmospheric electricity, earth-currents, polar lights, and atmospheric-electric "strays"). The section was accordingly established at the meeting of the Union on July 23 and on July 24, an organizing meeting was held, of which the minutes are as follows:

MINUTES OF THE MEETING OF THE SECTION OF TERRESTRIAL MAGNETISM AND ELECTRICITY AT BRUSSELS, JULY 24, 1919.

The meeting was held at the Palais des Académies, on July 24, 1919, from 2:30 to 5 P. M., Professor A. Tanakadate being temporary chairman, and Dr. L. A. Bauer serving as temporary secretary. The following were initially present: A. Angot, L. A. Bauer, William Bowie, Charles Chree, Frank Dyson, H. Lamb, G. W. Littlehales, Luigi Palazzo, A. Riccò, Capt. Edward Simpson, A. Tanakadate, H. H. Turner, and G. W. Walker. Messrs. Dyson, Lamb, Simpson, and Turner were obliged to leave later because of other meetings.

The Section first discussed the kind of work to be undertaken, and Dr. Chree accordingly was requested to inform the Section regarding the work and status of the Executive Bureau of the pre-war International Commission on Terrestrial Magnetism, he having been a member of that Bureau. He briefly explained the following work of the Bureau:

a. Preparation and publication of lists of magnetically-quiet and of magnetically-disturbed days by Dr. E. van Everdingen of Holland;
b. Comparison of magnetic instruments;
c. Exchange of magnetic curves.

Messrs. Angot, Bauer, Palazzo, Tanakadate, and Walker contributed to the discussion of these topics. It was then resolved:

I. That a Committee be appointed to consider the best method of securing an adequate comparison of the magnetic instruments in use in different countries, and to consider as to the best method of measuring the magnetic elements in absolute units.
II. That the Section of Terrestrial Magnetism and Electricity concurs in the resolution of the Meteorological Section that international work in atmospheric electricity should be as

far as possible placed under the direction of a Committee nominated partly by the Section of Terrestrial Magnetism and Electricity, and partly by the Section of Meteorology.

III. That the Section of Terrestrial Magnetism and Electricity would welcome co-operation with the International Union of Scientific Radio-Telegraphy in the investigation of electric phenomena of the higher atmosphere.

IV. That a Committee be appointed on the systematic exchange of magnetic curves.

V. That special Committees be appointed from time to time for the investigation and report on specific problems in terrestrial magnetism and electricity.

VI. That the Section of Terrestrial Magnetism and Electricity would welcome co-operation with the International Astronomical Union in investigating the relationships between solar and terrestrial magnetic and electric phenomena.

After the Section had expressed the opinion that it would be well to defer complete organization of the Section, and of the committees to be appointed, until the neutral countries have joined the International Geodetic and Geophysical Union, the following officers[1] were elected in accordance with the Statutes of the Union:

> A. Tanakadate (Japan), president; Charles Chree (Great Britain), vice-president; Louis A. Bauer (United States of America), secretary and director of the Central Bureau.

It was next resolved:

VII. That the ex-officio members of the Executive Committee be empowered to elect additional members to serve until the next ordinary meeting of the Union.

VIII. That the Executive Committee consult with the Executive Committees of other Sections of the Union and report to the General Secretary of the Union the amount of funds annually required by the Section during the period of the present Convention.

The meeting adjourned at 5 P. M.

(Signed) A. Tanakadate, *President.* (Signed) Louis A. Bauer, *Secretary.*

[1]Prof. Tanakadate was nominated for the presidency by Dr. Bauer, who, in turn, was nominated for the same office by Prof. Tanakadate but withdrew his name. The nomination of Dr. Chree for vice-presidency was made by Major Bowie and seconded by Dr. Bauer. Before consenting to serve as secretary and director of the Central Bureau, Dr. Bauer stated his conception of the responsibilities of the office and that he would have to rely upon the united co-operation of his colleagues.

Minutes of Meeting of Executive Committee of Section on Terrestrial Magnetism and Electricity, Brussels, July 28, 1919.

At a meeting of the present Executive Committee (Tanakadate, Chree, and Bauer) of the Section on Terrestrial Magnetism and Electricity on July 28, 1919, the following ten committees were decided upon in order to carry into effect, as soon as possible, the resolutions of July 24. The full composition of the committees was deferred until complete organization of the Section has been effected after the entrance into the Union of the countries to be invited by the International Research Council.

1. *Committee on Comparisons of Magnetic Instruments and Methods of Absolute Magnetic Measurements:* L. A. Bauer (chairman).
2. *Committee on International Work in Atmospheric Electricity:* C. T. R. Wilson (chairman).
3. *Committee on Co-operative Investigation with Radio-Telegraphists of Electric Phenomena of Upper Atmosphere.*
4. *Committee on Exchange and Methods of Measurement of Magnetic Curves:* C. Chree (chairman).
5. *Committee on Magnetic Characterization of Days.*
6. *Committee on Co-operative Investigation of Solar and Terrestrial Magnetic and Electric Phenomena.*
7. *Committee on Diurnal Variations of Terrestrial Magnetic Phenomena:* A. Schuster (chairman).
8. *Committee on Magnetic Surveys, Charts, and Secular Variation:* L. A. Bauer (chairman).
9. *Committee on Publication and Exchange of Magnetic Observatory Data.*
10. *Committee on Polar Lights and Earth Currents.*

The Executive Committee further decided to recommend to the International Research Council that the annual funds desirable for the Section when fully organized and per contributing unit would be about 400 francs.

Louis A. Bauer,
Secretary and Director of Central Bureau.

From the above it will be seen that the committee-plan of distribution of international researches in terrestrial magnetism and electricity, as adopted by the International Astronomical Union, was also followed in section D, as, in fact, generally in the other sections, as far as they could be organized.

Annual Funds. The basis of votes and financial contributions is that adopted by the International Research Council, viz.:

Population of Countries	Number of Votes on Scientific Questions	Number of Units of Financial Contributions
Less than 5 millions	1	1
Between 5 and 10 millions	2	2
" 10 " 15 "	3	3
" 15 " 20 "	4	5
Over 20 millions	5	8

Each country may include the native inhabitants of its colonies in its population. Self-governing dominions have a separate voting power according to above scale. It is expected that there will be at least 50 contributing units, hence, the total annual funds which may be available for the international researches of a Union, or of a Section, will be about 50 times the unit of contribution, whatever that be finally. The funds are to be obtained, by the International Research Council, through a national research organization, academy, or governmental agency.

It is not possible, under the present statutes, for a country to join only one or more of the sections of the Geodetic and Geophysical Union. In this respect, then, the organization of the new international associations (Unions) differs from the pre-war ones—a country could join, for example, only the International Geodetic Association, not, necessarily, also the International Seismological Association. As a matter of fact, however, practically all civilized countries were adherents of the various existing international bodies. Hence the aggregate money contribution per country joining the new international bodies will probably not be any more, more likely less, than under the old system.

The organization of the new international bodies may appear to be not as simple, or perhaps not even as independent, as the former ones. Thus, for example, instead of having such a brief and convenient name as "International Geodetic Association" we would have now "Section of Geodesy of the International Geodetic and Geophysical Union." (The International Research Council does not insist upon having its name also added.)

Most likely there will naturally come into use simplified designations, as, for example: International Geodetic Section (or Com-

mittee), International Seismological Section (or Committee), International Magnetic and Electric Section (or Committee), etc. This would conform to the corresponding names for the "national sections," as they have been tentatively called in the United States, or "national committees," as they are called in England and France.

The basic idea of retention of the name of section (or of committee) is, of course, that the particular branch of geophysics represented by the section is to be considered as but a part of the broad, general subject of geophysics. The fruitful, fundamental idea is that there will be at least once in three years a general symposium on the main branches of geophysics, rather than independent, inco-ordinated meetings on special branches. In that respect there is certainly a great gain in the new organization of geophysical bodies over the old ones. And as far as independence is concerned, it is to be said that the manner of organization admits of much elasticity and large freedom of action of any section apart from the Union to which it may belong, or of the Union apart from the Council.

The present convention is to continue for twelve years, beginning January 1, 1920, subject to renewal and modification at the end of this period. The general meetings are to take place every three years when there will be opportunity for changes in organization or statutes, as future experience may suggest. It will not be necessary for a Union to meet at the same place as the Council, or for all the various Unions to meet together. A section may furthermore call a special meeting when found necessary.

The next general meeting of the International Geodetic and Geophysical Union is to be at Rome in 1922.

Palais des Académies at Brussels.
(Where the Meetings were held, July 18-28, 1919.)

UEBER DIE BESTIMMUNG DER INKLINATION MIT DEM INDUKTIONS-INKLINATOR.

VON W. ULJANIN.[1]

Gegenwärtig wird an den meisten magnetischen Observatorien der Inklinationswinkel mittels des Wild'schen Induktions-Inklinators bestimmt, der unbedingte Vorzüge vor dem Nadelinklinator besitzt. Dabei wird die Induktionsspule mittels biegsamer Welle in rasche Rotation versetzt und der durch einen Kollektor gleichgerichtete Induktionsstrom einem empfindlichen, starkgedämpften Galvanometer zugeführt. Die Rotationsaxe wird vorher nach einer Magnetnadel in die Meridianebene eingestellt und jetzt in derselben so geneigt, dass der Galvanometerstrom verschwindet. Dann fällt die Rotationsaxe in die magnetische Feldrichtung und der Inklinationswinkel wird direkt am Vertikalkreis abgelesen.

In der Praxis kommt es aber meistens vor, dass, bei empfindlichem und nicht ganz aperiodischem Galvanometer, die Nadel sich nicht auf einem bestimmten Ausschlag einstellt, sondern hin und her schwankt. In den verschiedenen Vorschriften[2] ist ohne weitere Begründung angegeben, dies sei ein Beweis dafür, dass die Rotationsaxe der Spule nicht genau in der Meridianebene liege. Dann soll durch Ausprobiren dieser Fehler beseitigt werden. Ferner wird, ebenfalls ohne nähere Erklärung, empfohlen, bei der Rotation nach rechts und nach links dieselbe Geschwindigkeit einzuhalten.

Dies veranlasste Dorsey[3] und später noch ausführlicher Pavlinov[4], theoretisch die Bedingungen zu untersuchen, unter welchen in der rotirenden Spule der Induktionsstrom entsteht und durch

[1] *Anmerkung.* Diese und die nächstfolgende Abhandlung sind eine abgekürzte Wiederherstellung zweier in Kasan für den Druck fertiggeschriebener Manuskripte. Ehe sie abgeschickt werden konnten, entfalteten sich in Kasan und dessen Umgegend schwere Episoden des in Russland wütenden Bürgerkrieges. Als nach fünfwöchentlichem Kampfe die Stadt von den Bolschewiki am 10. September eingenommen wurde, musste die Mehrzahl der den gebildeten Kreisen angehörenden Einwohner, besonders diejenigen, welche am öffentlichen Leben und an der damit verbundenen Organisation der Verteidigung der Stadt teilgenommen hatten, plötzlich aus Kasan flüchten, um ihr Leben zu retten. Eine Anzahl von Kasaner Professoren, und unter ihnen der Verfasser, fanden an der entfernten Sibirischen Universität Tomsk Aufnahme und Lehrtätigkeit. Leider können jetzt die zahlenmässigen Resultate der zweijährigen Beobachtungen nicht mitgeteilt werden, da alles Material in Kasan geblieben ist.

[2] Vergl. z. B. HAZARD, *Directions for Magnetic Measurements, Coast and Geodetic Survey, 1911.*

[3] *Terr. Mag.*, vol. 18, 1913, p. 1.

[4] PAVLINOV, *Recueil de Geophysique* 3, 1916, p. 53.

den Kollektor gleichgerichtet wird. Es stellt sich heraus, dass der Kollektor zur Fehlerquelle werden kann, wenn er den Wechselstrom nicht im richtigen Moment kommutirt. *Nullausschlag des Galvanometers beweist nicht notwendig Abwesenheit eines Induktionsstromes.* Wenn die Stromwendung im Momente des maximalen positiven und negativen Stromes geschieht, so bleibt bei genügender Rotationsgeschwindigkeit die Galvanometernadel in Ruhe. Beide Autoren verlangen, dass der Kollektor behufs genauer Justirung drehbar auf der Axe gemacht werde, während bei den besten Modellen (Schulze, Institut Carnegie, Cambridge Scientific Instrument Co.) der Kollektor fest mit der Axe verbunden ist. Ferner entsteht infolge der Selbstinduktion der Spule eine Phasendifferenz zwischen Strom und Spannung, welche von der Rotationsgeschwindigkeit abhängt, so dass streng genommen die Justirung des Kollektors für jede Geschwindigkeit eine andere sein muss. Zur Vermeidung des durch die Phasendifferenz entstehenden Fehlers schlägt Pavlinov vor, die Induktionsspule durch zwei gleiche Spulen zu ersetzen, welche mittels Zahnräder in entgegengesetzte Richtung gedreht und hintereinander geschaltet werden. Ein Blick auf die Abbildung des so abgeänderten Pavlinov'schen Inklinators zeigt, wie komplizirt dadurch die Konstruktions des Apparates wird. Endlich weisen beide Autoren auf die Möglichkeit der Entstehung von thermoelektrischen Strömen bei rascher Rotation an der Reibungsstelle der Schleifbürsten am Kollektor. Zu ihrer Vermeidung stellt Pavlinov Kollektor und Bürsten aus reinem Silber her.

Seit dem Jahre 1911 besitzt das Magnetische Observatorium der Universität Kasan einen vorzüglichen Induktions-Inklinator von G. Schulze in Potsdam. Bald bemerkte ich bei dessen Benützung die Schwierigkeiten, die der Kollektor mit sich bringt. Ich kam auch dazu, die Justirbarkeit desselben zu vermissen. Es gelang mir aber, sie zu vermeiden, ohne etwas am Apparate zu verändern, nur einfach dadurch, dass ich den Kollektor nicht als Stromgleichrichter benutzte. Ich kehrte einfach zur alten Weber'schen sogenannten Multiplikationsmethode zurück, bei der die Galvanometernadel, durch Hin- und Herdrehen der Spule um beinahe 180°, in Schwingungen versetzt wird. Jede Bürste bleibt immer mit derselben Kollektorhälfte in Berührung. Dann ist die einzige Bedingung eines Nullausschlages des Galvanometers das Zusammenfallen der Rotationsaxe der Spule mit der Richtung des Erdfeldes.

Wenn die Rotationsaxe mit dem Erdfeld den Winkel θ bildet, so ist, bei sonst gleichen Bedingungen, die elektromotorische Kraft der Induktion proportional $\sin\theta$ und sie ändert ihr Vorzeichen im Momente, wenn die Spulenaxe[5] die Ebene des Winkels θ passirt. Es sei die Figur auf der inneren Oberfläche einer Kugel gezeichnet, deren Radien auf ihr folgende Punkte markiren:

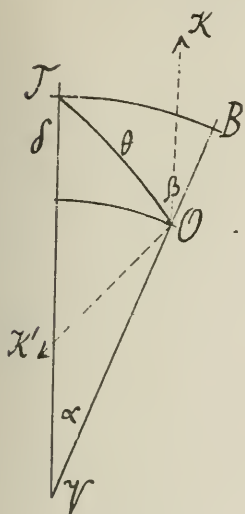

Fig. 1.

V, vertikal nach unten.
T, in der Richtung des Erdfeldes.
O, in der Richtung der Rotationsaxe der Spule.

Dann ist der Winkel $VT = i = 90 - I$, wo I den Inklinationswinkel bedeutet. Bezeichnen wir durch α den Azimutfehler und δ den Inklinationsfehler, und drücken wir durch sie die Winkel $\theta = OT$ und β, welchen die durch die Rotationsaxe gelegte Vertikalebene mit der Ebene des Winkels θ bildet. Das Dreieck TBO ist ein sphärisches, und es ergibt sich leicht

$$\cos\theta = \cos\delta\,(\sin^2 I + \cos^2 I \cos\alpha) + \sin\delta \sin I \cos I\,(1 - \cos\alpha)$$

$$\cos\beta = \frac{\sin^2 I + \cos^2 I \cos\alpha - \cos\theta\cos\delta}{\sin\theta \sin\delta}$$

und, da α und δ, somit auch θ sehr klein sind, unter Vernachlässigung der höheren Potenzen dieser Winkel

$$\theta^2 = \delta^2 + \alpha^2\cos^2 I \quad (1) \qquad\qquad \tan\beta = \frac{\alpha}{\delta}\cos I \quad (2)$$

Am Ringe, welcher die Axenlager der Spule trägt, wurde ein Holzarretir festgeklemmt, welches die Hin- und Herdrehung der Spule auf circa 140° einschränkte, derart, dass die Spulenaxe bis in die Richtungen OK und OK' zu stehen kam. Die Winkel BOK und VOK' waren circa 20°. Wie schon gesagt, ändert der Galvanometerausschlag sein Zeichen, wenn die Spulenaxe die θ-Ebene passirt, welche mit der Nullebene des Apparates den Winkel β bildet. Wenn also $\beta < 20°$ ist, ändert der Ausschlag sein Zeichen nicht bei Drehung der Spulenaxe von einem Arretir K zum anderen K', d. h. bei kleinen Probedrehungen in der Nähe der beiden Arretire bekommt man gleichgerichtete Ausschläge. Sobald

[5]Nicht zu verwechseln mit der "Rotationsaxe der Spule".

aber $\beta > 20°$ wird, geben diese kleinen Probedrehungen in unmittelbarer Nähe beider Arretire entgegengesetzte Ausschläge. β aber hängt vom Verhältniss $\frac{\alpha}{\delta}$ ab. Formel (2) gibt für $I = 70°$:

$$\beta = 15° \qquad 20° \qquad 25°$$

$$\text{für } \frac{\alpha}{\delta} = 0.78 \quad 1.06 \quad 1.36$$

Das Galvanometer war ein vierspuliges Dubois-Rubens'sches mit astatischem Magnetgehänge mittlerer Schwere mit ausgezogenen Kupferdämpfern.

Die Beobachtung geschieht folgendermassen. Die Axe des Vertikalkreises wird mittels Libelle horizontal justirt, sodann nach der Bussole die Nullrichtung *VB* des Apparates möglichst genau in die Meridianebene *VT* und die Rotationsaxe der Spule angenähert um den Inklinationswinkel geneigt. Wenn bei Hin- und Herdrehung der Spule zwischen den Richtungen K und K' kein Zeichenwechsel des Ausschlages erfolgt, ändert man die Neigung der Rotationsaxe so, dass δ kleiner wird; dadurch wird β grösser, und bald bemerkt man, dass der Ausschlagsinn in unmittelbarer Nähe beider Arretire verschieden ist. Dies bedeutet, dass $\beta > 20°$ ist. Nun wird mittels der Azimutschraube der Winkel α verkleinert, bis der Zeichenwechsel wieder verschwindet. Durch abwechselndes Verkleinern der beiden Winkel α und δ nähert man sich ganz systematisch der richtigen Einstellung der Rotationsaxe O in die Feldrichtung T, und zwar so weit, als es die Empfindlichkeit des Galvanometers erlaubt.

Zur raschen Arbeit, um jedesmal zu wissen, nach welcher Richtung die α-Mikrometerschraube (Azimuteinstellung) und die δ-Schraube (Inklination) zu drehen sind, ist es vorteilhaft, eine kurze Vorschrift folgender Art am Apparat anzubringen. "*Bezeichnungen.* 1) Rechtes Arretir heisst dasjenige, an welches die Spule stösst bei ihrer Rechtsdrehung. 2) Die Wirkung heisst positiv, wenn Rechtsdrehung der Spule Galvanometerausschlag nach grossen Zahlen gibt. *Regeln.* (Bei bestimmter, vorgeschriebener Klemmenverbindung des Galvanometers mit der Induktionsspule.) 1) Wenn am rechten Arretir die Wirkung positiv ist und am linken negativ, ist die Azimutschraube nach grossen Zahlen zu drehen. 2) Wenn an beiden Arretiren die Wirkung positiv ist (also kein Zeichenwechsel), ist die Inklinationsschraube nach grossen Zahlen zu drehen."

Die vollständige Inklinationsbestimmung, wie sie seit mehr als zwei Jahren am Magnetischen Observatorium der Universität Kasan mit Erfolg ausgeführt, wird, geschieht folgendermassen. Nach Justirung des Apparates mittels Libelle und Magnetnadel, wird die Rotationsaxe nach der Spulenlibelle vertikal gestellt und der Vertikalkreis abgelesen, dann nach der angegebenen Methode die Axe genau in die Feldrichtung gebracht und abermals der Vertikalkreis abgelesen. Dann wird der ganze Apparat um 180° gedreht und dieselben Einstellungen wiederholt. Das Mittel aus beiden Messungen gibt den gesuchten Inklinationswinkel. Genaue Versuche haben ergeben, dass es überflüssig ist, die Messung zu wiederholen nach Drehung der Induktionsspule um 180°, d. h. bei Berührung der Schleifbürsten mit den anderen Kollektorhälften. Somit kann das Holzarretir ein für allemal am Apparate festgeklemmt bleiben.

Die Vorteile der hier vorgeschlagenen Methode vor der üblichen Wild'schen Methode der kontinuirlichen raschen Drehung der Spule bestehen in folgendem. 1) Während bei der Wild'schen Methode nur die summarische Wirkung aller Induktionsströme auf das Galvanometer beobachtet wird, wird bei der Multiplikationsmethode die auf die Spule induzirend wirkende Feldkomponente nach Grösse und Vorzeichen untersucht. 2) Durch Beobachtung der Galvanometerausschläge wird die Rotationsaxe der Spule ganz systematisch nicht nur in die Inklinationsrichtung, sondern auch in die Meridianebene gebracht, und zwar in die letztere bedeutend genauer als nach der Magnetnadel, mit dem erwähnten Dubois-Rubens'schen Galvanometer bis auf circa 2′. 3) Die vom Kollektor herrührenden Fehler werden vermieden. 4) Bei demselben Galvanometer, mit geringer Dämpfung, ist die Multiplikationsmethode empfindlicher. 5) Der Wegfall der raschen Rotation ist von Vorteil für die Erhaltung der Axenlager and der Axe in gutem Zustande, der Axe, deren Richtung bis auf Teile der Minute genau bestimmt werden muss. Ausserdem fällt damit die Möglichkeit der Entstehung von Thermoströmen weg.

Tomsk, Januar 1919.

ELEKTRISCHE METHODE ZUR BESTIMMUNG DER HORIZONTALINTENSITAET DES ERDMAGNETISMUS.[1]

Von W. Uljanin.

1. EINLEITUNG.

In den letzten Jahren wurde von verschiedenen Seiten die Ausarbeitung der schon lange prinzipiell bekannten Methoden zur Bestimmung der Horizontalintensität in Angriff genommen, welche auf der Anwendung elektrischer Ströme beruhen. Vor drei Jahren veröffentlichte ich[2] in russischer Sprache meine diesbezüglichen Untersuchungen. In vorliegender Abhandlung sollen zusammen mit dem Inhalt jener Arbeit die seitherigen Erfahrungen mitgeteilt werden.

Schon sehr alt ist der Gedanke, den Stahlmagneten mit seinem veränderlichen und desshalb immer wieder zu bestimmenden magnetischen Moment durch eine stromdurchflossene Spule zu ersetzen. Eine solche Spule ist aber desshalb nicht früher in die Praxis der erdmagnetischen Beobachtungen eingeführt worden, weil die Mittel nicht vorhanden waren, den sie durchfliessenden Strom mit genügender Genauigkeit zu messen. Die bis jetzt an allen magnetischen Observatorien übliche klassische Gauss-Lamont'sche Methode hat ausser ihrer Komplizirtheit noch den nicht zu unterschätzenden Nachteil, zu ihrer Ausführung etwa 1½ Stunden zu erfordern. Desshalb ist die Ausarbeitung von Methoden wünschenswert, welche bei derselben Genauigkeit weniger Zeit und Mühe erfordern.

Eine Spule hat vor dem Magneten den grossen Vorteil, dass ihr magnetisches Feld, bei Unveränderlichkeit ihrer Form und Lage, nur von der Stärke des sie durchfliessenden Stromes abhängt. Diese kann man jetzt, dank der Vollkommenheit der Präzisionsinstrumente und der elektrischen Normalien, mit genügender Ge-

[1] Vergl. die Anmerkung zur vorhergehenden Abhandlung.

[2] W. Uljanin, *Recueil de Géophysique* 2, 1915, p. 51 (russ.).

[3] Tanakadate (Referat in *Terr. Magn.* 22, p. 51, 1917), *Phil. Soc.*, Glasgow, 1889. R. A. Lehfeld, *Phil. Mag.* (5) 33, 1892, p. 78. W. Watson, *Trans. Roy. Soc.*, 189, 1902, p. 431. W. A. Jenkin, *Phil. Mag.* (6), 26, 1913, p. 752. L. A. Bauer, *Terr. Mag.*, 19, 1914, p. 14. A. Schuster, *ibid.* p. 19.

nauigkeit reguliren und messen. Da nun das magnetische Feld der Spule, mit dem das Erdfeld verglichen wird, bekannt ist, so fällt die eine der beiden Messungen der Gauss-Lamont'schen Methode weg, und es bleibt übrig nur die Messung entweder der Schwingungsdauer oder des Ablenkungswinkels. Bekanntlich bildet die Messung der Schwingungsdauer den schwierigeren und grössere Aufmerksamkeit fordernden Teil - der Beobachtungen. Desshalb sind, wie es ganz richtig L. A. Bauer bemerkt, diejenigen elektrischen Methoden vorzuziehen, welche auf der Messung des Ablenkungswinkels beruhen.

Durch Ersetzung bei der Lamont'schen Methode des Stahlmagneten durch eine Spule entsteht die von verschiedenen Seiten vorgeschlagene Methode des Sinusgalvanometers. Dies ist auch die Methode, die ich ausgearbeitet habe.

2. INSTRUMENT UND BEOBACHTUNGSMETHODE.

Nach vielen Vorversuchen wurde zur Strommessung, als einzig brauchbar, die Kompensationsmethode gewählt. Dabei wird der die Spule speisende Strom i durch einen Normalwiderstand R geleitet, an dessen Enden ein Normalelement E angelegt ist. Bei vollständiger Kompensation des Stromes im Normalelementen-Zweig ist $i = E/R$.

Zur Untersuchung der Methode wurde ein Wiedemann'sches Galvanometer von Edelmann umgebaut. Das ganze Galvanometer mit Glockenmagnet in kugelförmigem Kupferdämpfer, und Schiene mit verschiebbaren Spulen wurde von seinem Stativ abgenommen und auf einen drehbaren Teilkreis von 30 cm. Durchmesser montirt. Mittels Messingarm wurde am Galvanometer ein leichtes Fernrohr mit kleiner Elfenbeinskala befestigt. Sehr vorteilhaft erschien die Möglichkeit, ohne besonderes Galvanometer für die Kompensationsmessung auszukommen, und dazu denselben abgelenkten Glockenmagnet zu verwenden. Zu diesem Zweck wurden auf die Schiene zwei Paar Spulen befestigt, ein Paar entferntere als Ablenkungsspulen, welche den Gauss'schen Ablenkungsmagneten ersetzen, und das zweite Paar dicht an den Kugeldämpfer als Spulen eines empfindlichen Nullgalvanometers. Zur Sicherung einer unveränderlichen Lage der äusseren Spulen wurden dieselben an die Schiene festgeklemmt und ausserdem noch miteinander mittels zweier Holzleisten fest verschraubt. Der den Glockenmagnet und einen drehbaren Spiegel tragende Aluminiumdraht war an einem dünnen Bronzeband aufgehängt.

Die ganze Versuchsanordnung ist aus der Figur 1 ersichtlich. Die Akkumulatorenbatterie B liefert den Strom für die Ablenkungsspulen A; derselbe wird mittels des Gleitwiderstandes W_1 grob, und der Platindrähte W_2 mit Quecksilberbrücke Q_2 fein regulirt. Das Normalelement E wird über das innere Spulenpaar G an die Enden eines genau bestimmten Widerstand $R+r$ angelegt. K und K_1 sind zwei Quecksilber-Stromwender; dieselben sind auf einem gemeinschaftlichen Brett montirt, so dass sie nur zusammen gewendet werden können, um eine für das Normalelement schädliche falsche Schaltung unmöglich zu machen. S ist ein Stromschlüssel und Z ein grosser Vorschaltwiderstand zum Schutze des Normalelementes, welcher durch den Schlüssel P erst nach erreichter ungefährer Kompensation ausgeschlossen wird.

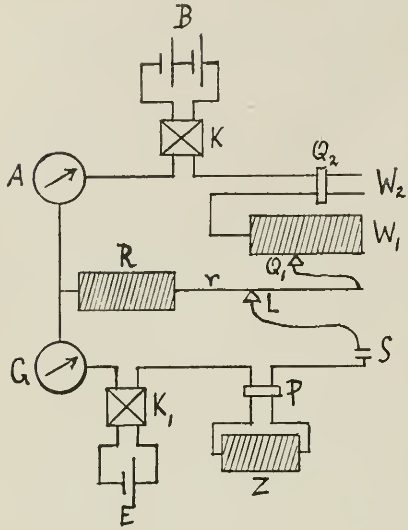

Fig. 1

Die Beobachtung kann auf zweierlei Art geschehen: 1. Durch die Ablenkungsspulen A wird ein Strom von immer derselben Stärke geleitet, welcher das Normalelement an den Enden immer desselben Widerstandes R genau kompensirt, und der Winkel α am Teilkreis gemessen, um welchen das Galvanometer gedreht werden muss, damit im Fernrohr der Skalennullpunkt wieder einspielt. 2. Umgekehrt kann man das Galvanometer um immer denselben Winkel α, etwa bis zu festeingestellten Arretiren, drehen und die Stromstärke in A so reguliren, dass der Skalennullpunkt richtig einspielt. Dann muss man jedesmal den durch den Gleitkontakt abgegrentzen Widerstand $R+r$ ablesen.

Es ist leicht zu sehen, dass die Empfindlichkeit mit dem Ablenkungswinkel α zunimmt und unendlich wird für $\alpha = 90°$. Dann kompensirt das Spulenfeld genau das Erdfeld, die Richtkraft auf den Magneten ist gleich Null, er befindet sich im indifferenten Gleichgewicht. Die von A. Schuster beschriebene Methode ist prinzipiell identisch mit der hier an zweiter Stelle angegebenen, wobei er aber einen sehr grossen Ablenkungswinkel, etwa 88°

vorschlägt. Es schien mir zweifelhaft, dass es vorteilhaft sei, mit einer so schwachen Richtkraft zu arbeiten, und in der Tat zeigte der Versuch, dass schon bei einem Ablenkungswinkel von 82° der Magnet sich sehr langsam und unbestimmt einstellte.

3. BERECHNUNG DER HORIZONTALINTENSITAET.

Die Horizontalintensität wird durch folgende einfache Formel ausgedrückt

$$H = \frac{FE}{R \sin \alpha}$$

wo α den Winkel bedeutet, um den das Galvanometer gedreht werden muss, damit bei stromdurchflossenen Ablenkungsspulen die Magnetaxe senkrecht zur Spulenaxe steht, E die elektromotorische Kraft des Normalelementes, R den Widerstand, an welches angeschlossen das Normalelement kompensirt wird, und endlich F der sogenannte Reduktionsfaktor des Galvanometers.

Weston'sche Normalelemente sowie Normalwiderstände aus Manganin können von verschiedenen Fabrikanten mit Zeugnissen der Physikalisch-Technischen Reichsanstalt in Berlin oder anderer ähnlicher Staatsinstitute bezogen werden. Diese Zeugnisse enthalten die absoluten Werte dieser Normalinstrumente mit ihren Temperaturkoeffizienten. Es ist bewiesen,[4] dass bei sachgemässer Behandlung die Weston-Elemente ihre elektromotorische Kraft unbegrenzt konstant halten.

Was die Galvanometerkonstante F betrifft, so kann sie aus den Dimensionen und der Lage der Ablenkungsspulen berechnet werden, wenn diese passend konstruirt sind. Vorteilhaft sind für diesen Zweck besondere Anordnungen[5] (wie z. B. nach Gaugain oder Helmholtz), für welche die Hauptkorrektionsglieder aus den Formeln wegfallen. Ausserdem ist dafür nötig, dass die Dimension der Spulen und ihre Entfernung vom Magneten gross seien im Vergleich zu seiner Länge. Aber diese Bedingungen sind unvereinbar mit den Forderungen, welche an ein transportables, bequemes, und empfindliches Beobachtungsinstrument gestellt werden. Dieselben sind: 1) Absolute Unveränderlichkeit der Form und Lage der Ablenkungsspulen. 2) Ein möglichst homogenes Spulenfeld an der Stelle des Magneten, damit kleine Verschiebungen desselben das Resultat nicht beeinflussen. 3) Mässige Dimension und Gewicht bei genügender Empfindlichkeit, um mit schwachen Strömen auszukommen, welche die Spulen nicht merklich er-

[4] TAEGER UND LINDECK, Ann. d. Ph. 5, 1901, p. 1.
[5] MASCART ET JOUBERT, *Electricité et Magnétisme*, 2, 1897, p. 119.

wärmen. Meiner Ansicht nach wäre es verfehlt, ein Galvanometer zur Bestimmung der Horizontalintensität konstruiren zu wollen, an welchem ganz selbständig die Konstante F bestimmt werden könnte. Zweckmässiger ist es, den Wert von F abzuleiten aus dem Vergleich des Galvanometers mit einem speziell zur Messung von Stromstärken gebauten Normalinstrument. Ebenso wie es niemandem einfällt, die absolute Grösse von Masstäben, Gewichtssätzen und Widerständen anders zu bestimmen, als durch Vergleich mit entsprechenden Normalien, so muss auch der Reduktionsfaktor eines jeden Sinusgalvanometers, der für die absolute Messung der Horizontalintensität bestimmt ist, aus dem Vergleich mit einem Normalinstrument bestimmt werden. Am passendsten wäre ein Tangens- oder Sinusgalvanometer mit Spulen, die eine genaue Ausmessung ihrer Dimensionen gestatten, welches mit dem zu prüfenden Instrument in einen Stromkreis eingeschaltet wird. Es kann aber auch F aus den gleichzeitigen Messungen von H an einem Magnetometer bestimmt werden. Eine Vergleichsreihe mit einem auf das internationale Standard zurückgeführten Magnetometer gibt die Grösse F des Sinusgalvanometers in diesen internationalen Einheiten. Infolge der Temperaturausdehnung der Ablenkungsspulen und ihrer Träger wird allgemein F eine Funktion der Temperatur sein. Ihr Temperaturkoeffizient muss experimentell durch Vergleichsbeobachtungen bei verschiedenen Temperaturen bestimmt werden.

Vergleicht man hiemit die grosse Anzahl von Konstanten und Koeffizienten, welche zur Bestimmung der Horizontalintensität mit dem Magnetometer bekannt sein müssen, so sieht man unmittelbar den Vorzug der galvanometrischen Methode. Es sei noch auf folgenden Umstand beim Magnetometer hingewiesen. Prinzipiell sollte jedes Magnetometer, für welches alle Konstanten genau bestimmt worden sind, in der Lage sein, ganz selbständig den absoluten Wert der Horizontalkomponente zu liefern auf Grund der verwendeten Normalien von Länge, Masse und Zeit. In Wirklichkeit aber zeigen die verschiedenen Magnetometer, trotz der sorgfältigsten Bestimmung aller Grössen, welche in die Formeln eingehen, kleine Abweichungen untereinander. Dieselben können nur aus Vergleichungen der verschiedenen Instrumente miteinander bestimmt werden und müssen als Korrektionen in die Beobachtungsresultate eingeführt werden. Also ist auch bei der Magnetometer-Methode eine Vergleichung der Beobachtungsinstrumente mit einem Normalinstrument nicht zu umgehen.

Alle diese Umstände zeigen deutlich den prinzipiellen Vorteil der galvanometrischen Methode vor der magnetometrischen. Anstatt der so komplizirten und manchen Ungenauigkeiten unterworfenen Ableitung der gesuchten Grösse *H* von beglaubigten Kopien des Centimeters, des Gramms und der Sekunde, wird bei der galvanometrischen Methode die Horizontalintensität auf Grund der Galvanometerkonstanten und der bei den Messungen verwendeten ebenso beglaubigten Kopien des Volt und des Ohm bestimmt.

4. VERSUCHE MIT DEM PROVISORISCHEN INSTRUMENTE.

Das oben beschriebene Sinusgalvanometer wurde auf dem magnetischen Observatorium der Universität Kasan im Walde bei Sajmistsche geprüft. Da auf dem Observatorium Wild-Edelmann'sche Variationsinstrumente aufgestellt sind, deren Angaben beständig auf die mittels eines Universalmagnetometers des Instituts Carnegie erhaltenen absoluten Werte zurückgeführt werden, so gibt eine einfache Ablesung des Bifilars während der Beobachtung am Sinusgalvanometer den absoluten Wert der Horizontalintensität.

Als Hilfsinstrumente dienten: 1) Ein Präzisionsstöpselrheostat von O. Wolff in Berlin mit Prüfungsschein der Ph.-T. Reichsanstalt. 2) Ein Normalwiderstand aus Manganin von 750 Ohm. 3) Ein Kohlrausch'scher Brückendraht auf feststehendem vertikalem Marmorzylinder, beide letzten Apparate von Leeds & Northrup in Philadelphia. 4) Ein Weston'sches Standard-Normalelement von der Weston Company in Berlin mit Prüfungsschein des Hauptbüreaus für Mass und Gewicht in Petersburg. 5) Zwei selbsthergestellte Weston'sche Normalelemente mit überschüssigem Cadmiumsulfat.

Diese drei Elemente wurden nach der Kompensationsmethode in Petroleumbädern verschiedener Temperatur miteinander verglichen. Der Prüfungsschein gilt für die elektromotorische Kraft des Standard-Elementes.

$$\text{St. E.} = 1.01893 + 0.00001 \text{ intern. Volt (zw. } 18^\circ \text{ u. } 31^\circ).$$

Aus dem Vergleich mit diesem ergab sich für beide selbstverfertigte Normalelemente folgender genau gleicher Wert

$$\text{N. E.} = 1.01903 - 0.00004\,(t - 20).$$

Von Zeit zu Zeit wurden diese drei Elemente miteinander verglichen und eine sehr gute Konstanz ihrer gegenseitigen Verhält-

nisse gefunden, woraus mit grosser Wahrscheinlichkeit geschlossen werden kann, dass sie ihre E.-M. Kraft über drei Jahre lang unverändert behalten haben. Ich muss hier ausdrücklich auf den grossen Vorzug der Standard Weston-Elemente mit bei 4° gesättigter Cadmiumsulfatlösung gegenüber den gewöhnlichen Weston-Elementen mit Ueberschuss an festem Cadmiumsulfat hinweisen. Die letztern besitzen einen nicht zu vernachlässigenden Temperaturkoeffizienten; um denselben aber mit Erfolg berücksichtigen zu können, ist es durchaus notwendig, das Element längere Zeit, etwa zwei Stunden, bei der neuen Temperatur zu halten, damit die derselben entsprechende Konzentration der Cadmiumsulfatlösung sich einstellt. Es hat sich nämlich ergeben, das beim Uebertragen des Elementes in ein Bad anderer Temperatur seine E.-M. Kraft nur langsam den dieser Temperatur entsprechenden Wert annimmt. Bei der Benützung eines solchen Elementes am Sinusgalvanometer, natürlich ohne Temperaturbad, ist die anzubringende Temperaturkorrektion sehr unsicher. Dem gegenüber ist das Standard-Element zwischen 18° und 31° bis zu einer Einheit der fünften Dezimale von der Temperatur unabhängig und ist desshalb für unsere Zwecke ausschliesslich zu verwenden.

Um eine rasche Aufstellung des Sinusgalvanometers zu ermöglichen, muss der Magnetspiegel ein für allemal so justirt werden, dass, bei Einstellung des Nullskalenteils auf das Fadenkreuz, die Magnetaxe genau senkrecht steht zur Spulenaxe. Dafür ist aber notwendig, dass die Unveränderlichkeit der Lage des Fernrohres zu den Spulen sowie des Spiegels zum Magneten gesichert sei. Dies vorausgesetzt, kann man folgendermassen verfahren. Man stellt, durch Drehen sowohl des ganzen Galvanometers als auch des Torsionskopfes, Spulenaxe und Magnetaxe in den Meridian, was daran erkannt wird, dass ein Strom in den Ablenkungsspulen den Magneten nicht ablenkt. Zu empfehlen ist, dabei ein besonderes Fernrohr zu benützen, um den Magnetspiegel für diesen Zweck nicht um 90° drehen zu müssen. Dann dreht man aus dieser Meridianstellung das ganze Instrument nach dem Teilkreis genau um 90°, so dass jetzt die Spulenaxe senkrecht zum Meridian zu stehen kommt, und den Torsionskopf um 90° zurück, um die entstandene Torsion des Aufhängebandes aufzuheben.

Die Bestimmung der Horizontalintensität geschieht folgendermassen. *1. Methode des konstanten Widerstandes R.* Der durch die Widerstände W_1 und W_2 ungefähr passend regulirte Strom von zwei Edison-Akkumulatoren wird durch die Ablenkungsspulen geleitet

und das Galvanometer so weit gedreht, bis die Skala im Fernrohr sichtbar ist. Dann wird der Strom nachregulirt, bis das an den Normalwiderstand $R = 750$ Ohm angelegte Normalelement genau kompensirt ist, d. h. bis ein Schliessen des Schlüssels S keinen Ausschlag verursacht. Bei dieser Stromstärke wird durch Nachdrehen des Galvanometers der Nullstrich aufs Fadenkreuz eingestellt und die Nonien abgelesen. Hierauf kommutirt man den Strom durch Drehen des Doppelkommutators KK_1, und wiederholt alles mit Ausschlag nach der entgegengesetzten Seite. Der Winkel zwischen diesen beiden Einstellungen ist der doppelte Ablenkungswinkel α. 2. *Methode des konstanten Ablenkungswinkels* α. Am Teilkreis sind zwei Arretire befestigt, welche nach beiden Seiten eine Drehung des Galvanometers um genau den gleichen Winkel von ca. 69° zulassen. Das Galvanometer wird bis zum Anschlag an eines der Arretire gedreht, und der Batteriestrom so regulirt, dass der Nullstrich auf das Fadenkreuz fällt. Zum Normalwiderstand R ist jetzt der Kohlrausch'sche Brückendraht hinzugefügt, von dem ein solcher Teil r durch Verschiebung des Gleitkontaktes L abgegrenzt wird, dass beim Schliessen des Schlüssels S kein Ausschlag erfolgt. Das Normalelement ist jetzt am Widerstand $R+r$ kompensirt. Der Widerstand r wird abgelesen und alles nach Kommutiren des Stromes wiederholt. Im allgemeinen wird r in beiden Fällen etwas verschieden ausfallen, weil infolge der Variation der Deklination die Ablenkungswinkel nach beiden Seiten nicht ganz symmetrisch zum Meridian bleiben. Das Mittel aus beiden Ablesungen gibt den Zusatzwiderstand r.

Bei fertig aufgestelltem Instrument erfordert die ganze Bestimmung der Horizontalintensität nach der 1. Methode 5 bis 10 Minuten, nach der 2. Methode weniger als 5 Minuten wegen Wegfalls der Nonienablesungen und rascherer Erreichung der vollen Kompensation.

Zur Prüfung des Instrumentes und der Methode wurde jedesmal nach Erreichung der vollen Kompensation das Bifilar abgelesen und der Reduktionsfaktor F berechnet. Seine Konstanz bei verschiedenen Werten von H, R, E und α beweist die Genauigkeit der erhaltenen Resultate.

In der oben erwähnten russischen Abhandlung ist die Reihe von Beobachtungen mitgeteilt, welche im Frühjahr und Sommer 1915 gemacht worden sind. Dieselben sind beinahe ausschliesslich nach der 1. Methode ausgeführt worden. Sie zeigen eine ausgezeichnete Konstanz der Grösse F, solange an der Lage und Befes-

tigung der Ablenkungsspulen nichts verändert wurde. Daraus sei nur eine Reihe von 17 Beobachtungen vom 9 bis 18 August erwähnt, aus welcher sich ergibt.

$$F = 122.053 \pm 0.0057.$$

Dass ein solcher mittlerer Fehler für F zulässig ist, wenn H, wie üblich, bis auf $\frac{1}{10000}$ genau, oder, für $H = 0.2$, bis auf 2γ bestimmt werden soll, ergibt sich aus folgenden Ueberlegungen.

Aus
$$H = \frac{FE}{R \sin \alpha}$$
bekommt man durch logarithmische Differenzirung
$$\frac{dH}{H} = \frac{dF}{F} + \frac{dE}{E} - \frac{dR}{R} - \cot g \alpha d\alpha$$
und der mittlere Fehler wird
$$\frac{\delta H}{H} = \pm \sqrt{\left(\frac{\delta F}{F}\right)^2 + \left(\frac{\delta E}{E}\right)^2 + \left(\frac{\delta R}{R}\right)^2 + \left(\cot \alpha\, \delta\alpha\right)^2}$$
wir dürfen annehmen:
$$\frac{\delta E}{E} = 2\times10^{-5}, \frac{\delta R}{R} = 2\times10^{-5},\ \delta\alpha = 20'' = \frac{20''\pi}{180^\circ} = 10^{-4},\ \cot 70^\circ\, \delta\alpha = 3.6\times10^{-5}$$
und für $\frac{\delta H}{H} = 10^{-4}$ erhalten wir
$$\frac{\delta F}{F} = \pm\ 0.9\times10^{-4}$$
und für unseren Fall, für $F = 122$, $\delta F = 0.011$.

Wir sehen, dass der aus den Beobachtungen abgeleitete mittlere Fehler der Konstanten F kleiner ist, als zulässig für die geforderte Genauigkeit von H.

Seitdem ist während der letzten zwei Jahre eine grosse Anzahl von Beobachtungen angestellt worden, wobei nebeneinander beide Methoden verwendet wurden. Der Versuch hat gezeigt, dass sie an Genauigkeit vollständig gleichwertig sind. Die Wahl der einen oder anderen wird von den besonderen Verhältnissen abhängen. Wenn eine grosse Anzahl von Messungen, besonders im Observatorium, zu machen sind, ist die 2. Methode vorzuziehen, weil die Messung leichter und rascher erfolgt. Bei Feldmessungen möchte ich jedoch der 1. Methode den Vorzug geben wegen der einfacheren Ausrüstung infolge Wegfalls des Brückendrahtes.

Leider können hier die Resultate dieser ausgedehnten Beobachtungsreihen, aus dem oben erwähnten Grund, zahlenmässig nicht mitgeteilt werden. Das Hauptergebniss lässt sich aber folgender-

massen zusammenfassen. Aus etwa 200 Messungen wurde der wahrscheinlichste Wert des Reduktionsfaktors F berechnet. Was den Temperaturkoeffizienten von F betrifft, so muss er sehr klein sein, da keine Abhängigkeit dieser Grösse von der Temperatur bemerkt werden konnte, obgleich Unterschiede der Zimmertemperatur bis zu 10° notirt waren. Speziell den Temperaturkoeffizienten von F zu bestimmen, bei künstlicher Aenderung der Temperatur innerhalb grösserer Grenzen, bei diesem provisorischen Sinusgalvanometer hielt ich für überflüssig, da bei demselben die Unveränderlichkeit der Lage der Ablenkungsspulen nicht genügend gesichert ist. Dieser wahrscheinlichste Wert von F wurde benützt, um aus jeder Beobachtung die Horizontalintensität H zu berechnen und aus ihr den Wert des Normalskalenteils des Bifilars zu bestimmen. Seit den letzten zwei Jahren wird am Kasaner Observatorium, vor und nach jeder magnetometrischen Bestimmung der Horizontalintensität, vom Beobachter je eine Messung derselben am Sinusgalvanometer ausgeführt. Und es hat sich unzweideutig herausgestellt, dass der aus den letzteren abgeleitete Wert des Normalskalenteils des Bifilars im allgemeinen eine etwas bessere Konstanz aufweist, als der aus den magnetometrischen Beobachtungen abgeleitete.

Aus allem hier Mitgeteilten kann man mit Sicherheit schliessen, dass die galvanometrische Methode in der Lage ist, den absoluten Wert der Horizontalintensität mindestens mit derselben Genauigkeit zu geben, als die magnetometrische Methode. Da nun überdies die Bestimmung von H am Galvanometer bedeutend rascher und leichter erfolgt, als am Magnetometer, so können wir mit vollem Rechte behaupten, dass die hier ausgearbeitete elektrische Methode verdient, die klassische Gauss-Lamont'sche Methode überall zu ersetzen, sowohl bei Beobachtungen auf Observatorien, als auch bei magnetischen Feldaufnahmen.

5. DAS PROJEKTIRTE SINUSGALVANOMETER.

Auf Grund der mit diesem provisorischen Instrumente gesammelten Erfahrungen wurde folgendes Sinusgalvanometer projektirt, dessen Ausführung wegen der ungünstigen äusseren Verhältnisse leider bis jetzt nicht stattfinden konnte.

Damit das Spulenfeld in der Mitte möglichst homogen sei und infolge dessen eine kleine Verschiebung des Magneten ohne Einfluss auf das Resultat sei, wurde die Helmholtz'sche Spulenanordnung gewählt. Die Ablenkungsspulen von 10 cm. Durchmesser

aus seidenumsponnenem Kupferdraht werden in zwei Rinnen von quadratischem Querschnitt gewickelt, welche auf einem dickwandigen Messingzylinder in gegenseitiger Entfernung von 5 cm. eingedreht sind. Die fertig gewickelten Spulen werden mit Schellackfirniss durchtränkt und im Vakuum erwärmt, damit alle Zwischenräume zwischen den Drähten mit festem Schellack ausgefüllt werden, zur Erreichung einer absoluten Unveränderlichkeit in der Lage der einzelnen Windungen und ihrer Unempfindlichkeit gegen Feuchtigkeit. Konzentrisch innerhalb des Messingrohres, in unmittelbarer Umgebung des Zentrums, ist ein zweites Paar von kleineren Spulen angebracht zur Prüfung der Kompensation des Normalelementes. Die Aufhängung besteht aus einem Aluminiumstift mit einem kleinen Glockenmagnet am unteren und einer leichten, mikrometrisch justirbaren Spiegelfassung am oberen Ende. Die Glockenform wurde für den Magneten gewählt, weil bei derselben bei kleiner Entfernung der Pole das magnetische Moment verhältnissmässig stark ist. Diese Aufhängung ist an einem dünnen Bronzeband innerhalb einer Aufhängeröhre befestigt. Ihr oberer Teil ist aus Messing, trägt oben einen zentrirbaren und über einem kleinen Teilkreis drehbaren Aufhängekopf und ist in der Mitte mit einem drehbaren Spiegelkasten versehen. Der untere Teil des Aufhängerohres besteht aus einer Glasröhre, welche unten mit einem dickwandigen zylindrischen Kupferbecher abgeschlossen ist, der den Glockenmagnet dicht umschliesst und als Dämpfer dient.

Diese Aufhängeröhre mit dem Magneten wird durch eine oben im Messingzylinder angebrachte Oeffnung derart mittels Bajonettverschluss auf denselben befestigt, dass das Kupferende mit dem Magneten genau im Zentrum zu stehen kommt. An der einen Seite des Instrumentes ist an einem Messingarm ein leichtes Fernrohr mit kleiner Skala, an der gegenüberliegenden ein passendes Gegengewicht befestigt. Das ganze Instrument ist auf den drehbaren Tisch eines Teilkreises montirt.

Damit dieses projektirte Sinusgalvanometer, wie jedes Magnetometer, auch zur Bestimmung der Deklination dienen könne, ist ein kleiner hölzerner Magnetkasten vorgesehen, welcher an Stelle der oben beschriebenen galvanometrischen Aufhängeröhre, mit demselben Bajonettverschluss befestigt wird. Der Magnet ist die genaue Kopie desjenigen vom Universalmagnetometer des Instituts Carnegie, als Kollimator mit Skala und Linse in demselben bügelförmigen Halter. Zur Bestimmung des astronomischen

Meridians ist hinter dem Magnetkasten, genau wie beim Kew-Magnetometer, ein um zwei zu einander senkrechte Axen drehbarer Passagespiegel angebracht.

6. INDUKTOR FUER DIE BESTIMMUNG DER HORIZONTAL- UND VERTIKAL-INTENSITAET.

In der Mitte einer im Verhältniss zu ihrem Durchmesser langen Spule ist das magnetische Feld auf dem grössten Teile ihres Durchmessers homogen und kann aus ihren Dimensionen berechnet werden. Durch einen passenden Strom kann in einer solchen Spule die nach ihrer Axe gerichtete Komponente des Erdfeldes kompensirt werden. Die Stärke dieses Stromes kann nach der Kompensationsmethode mittels Normalelement und Normalwiderstand bestimmt werden. Als Kriterium für die Abwesenheit eines magnetischen Feldes innerhalb der Spule können verschiedene Anordnungen dienen.

1) Ein kleiner in der Mitte der Spule aufgehängter Magnet muss keine magnetische Richtkraft spüren, d. h. sich verhalten, wie ein unmagnetisches Stäbchen. Ersetzt man durch einen Magneten ein in der Spule senkrecht zum Meridian aufgehängtes Messingstäbchen, so ist der Spulenstrom so zu reguliren, dass der Magnet sich genau so einstellt, wie das Messingstäbchen.

2) Der Magnet kann ein für allemal in der Spule aufgehängt bleiben. Abwesenheit eines Magnetfeldes ist dann erreicht, wenn eine Drehung des Torsionskopfes um einen bestimmten Winkel den Magneten um genau denselben Winkel dreht. Am bequemsten für eine solche Beobachtung wäre das Fernrohr an die drehbare Aufhängeröhre zu befestigen, so dass es sich zusammen mit diesem dreht. Der Spulenstrom ist dann richtig regulirt, wenn bei beliebiger Drehung des Fernrohres das vom Magnetspiegel reflektirte Skalenbild sich nicht ändert.

3) Eine leichte Spule wird innerhalb der langen Spule so aufgehängt, dass ihr ein Strom zugeführt werden kann, und zwar mit ihrer Axe senkrecht zum Meridian. Wenn der die Horizontalkomponente kompensirende Strom richtig abgeglichen ist, muss ein durch die aufgehängte Spule geleiteter Strom keine Ablenkung derselben hervorrufen.

4) Das Feld innerhalb der Kompensationsspule kann mittels einer kleinen darin in Drehung gebrachten Induktionsspule untersucht werden, genau wie beim Induktionsinklinator. Die Induktionsmethode hat den grossen Vorteil vor den drei ersten Methoden,

dass sie in jeder Richtung im Raume angewendet werden kann. Angewendet auf die Horizontal- und Vertikal-Komponente ersetzt ein solcher Apparat ein Magnetometer und einen Inklinator.

Von den drei ersten wurde nur die 3. Methode geprüft. Eine flache Spule aus dünnem Kupferdraht von 3 cm. Durchmesser wurde zwischen dem Spulenpaar eines Wiedemann'schen Galvanometers an einem Bronzeband aufgehängt mit Stromableitung unten durch eine Spirale aus demselben Bronzeband. Die Anordnung war aber desshalb unbequem, dass infolge grossen Trägheitsmomentes und geringer Dämpfung die Ruhelage aus Umkehrpunkten bei grosser Schwingungsdauer bestimmt werden musste. Die 2. Methode konnte leider nicht versucht werden, weil die spezielle Montirung des Fernrohres nicht ausgeführt werden konnte.

Am meisten Interesse bietet offenbar die Induktionsmethode.[6] Vorerst wurde sie am vorhandenen Wild'schen Induktionsinklinator von Schulze geprüft. Zu diesem Zwecke wurden am Ringe, welcher die Axenlager für die Induktionsspule trägt, zwei grosse flache Spulen so befestigt, dass sie alle Drehungen und Bewegungen der Apparatteile gestatteten. Diese Spulen liefern offenbar nichts weniger, als ein homogenes magnetisches Feld im grossen Raum, den die Induktionsspule einnimmt. Für Vorversuche erwies sich aber der Apparat als sehr passend. Die Induktionsströme wurden nach der Multiplikationsmethode, genau wie bei Bestimmung der Inklination, beobachtet. Die Stärke des das Erdfeld annullirenden Spulenstromes wurde nach der Kompensationsmethode gemessen. Das Galvanometer konnte abwechselnd mit der Induktionsspule verbunden und in den Normalelementenzweig eingeschaltet werden.

Geprüft wurde der Apparat durch Vergleichung der Ströme in den Feldspulen, welche die Horizontal- und Vertikalkomponente annulliren. Ihr Verhältniss stimmte gut überein mit den Angaben der Variationsinstrumente, dem Bifilar und der Lloyd'schen Wage.

Nun wurde ein besonderer Apparat gebaut, bei welchem das Spulenfeld berechnet werden konnte. Auf einen Holzzylinder wurde eine 50 cm. lange Spule von 10 cm. Durchmesser in vier Lagen möglichst gleichmässig gewickelt. Diese Spule ist mit zwei Konussen versehen, mittels deren sie in einen Dreifuss entweder horizontal oder vertikal eingesetzt werden kann. Innerhalb der Spule sind ein Paar Messingschienen befestigt, auf denen sich ein

[6] Diese Methode wurde im Prinzip schon von G. MEYER (*Ann. d. Phys.* 64, 1898, p. 742(angegeben, von ihm aber nur an einem sehr groben Instrument versucht mit Amperemeter zur Strommessung.

Schlitten einschieben lässt, der die Axenlager einer Induktionsspule von 5 cm. Länge und 5 cm. Durchmesser trägt. Auf ihrer Axe sitzt ein Kollektorring, von dem zwei Schleifbürsten den Induktionsstrom abnehmen. Am herausragenden Ende des Schlittens ist eine kleine, mit Handgriff versehene Welle befestigt, welche mittels Schnurlauf ihre Drehungen der Induktionsspule mitteilt.

Die Induktionsströme wurden wiederum nach der Multiplikationsmethode beobachtet, wobei die genaue Einstellung der Spulenaxe in die Meridianebene durch Beobachtung der Richtung der Induktionsströme erreicht werden konnte, ähnlich wie bei der Bestimmung des Inklinationswinkels mit dem Induktionsinklinator. Die aus diesen Messungen und der berechneten Spulenkonstanten bstimmten Werte der Horizontal- und Vertikalintensität stimmten leidlich gut mit den an den Variationsinstrumenten abgelesenen überein. Es stellte sich aber heraus, dass für genaue Messungen notwendig eine Justirung der Rotationsaxe der Induktionsspule innerhalb der langen Feldspule möglich sein muss. Ausserdem, bei der Messung der Vertikalkomponente, muss die Möglichkeit einer genaueren Einstellung der jetzt horizontal liegenden Rotationsaxe der Induktionsspule in die Meridianebene vorgesehen sein, als es bei diesem provisorischen Apparat der Fall war. Die an diesen beiden Apparaten gemachten Erfahrungen gestatten, mit grosser Wahrscheinlichkeit den Schluss zu ziehen, dass diese Methode in der Lage ist, mit genügender Genauigkeit sowohl die Horizontal-, wie die Vertikalintensität zu liefern. Sie verdient also weiter ausgearbeitet zu werden.

Dass das Bedürfniss nach einer Methode empfunden wird, welche die Vertikalintensität direkt zu messen gestattet, anstatt sie, wie bisher, aus der Horizontalintensität und dem Inklinationswinkel zu berechnen, beweist z. B. der Versuch von N. Ogloblinsky,[7] ein Universalmagnetometer zu konstruiren, mit welchem, nach der Gauss-Lamont'schen Methode, nicht nur die Horizontal-, sondern auch die Vertikalintensität bestimmt werden kann, die letztere mit vertikalem, an einem horizontal gespannten Faden befestigten Magneten. Dass die hier beschriebene Induktionsmethode, besonders für die Bestimmung der Vertikalintensität, vor der magnetometrischen den Vorzug verdient, unterliegt meiner Ansicht nach keinem Zweifel.

[7]N. Ogloblinsky, *Berichte über Hydrographie*, 36, 1913 (russ.). *Terr. Mag.* 18, 1913, p. 185.

Tomsk, Januar 1919.

THE CRUISE OF THE CARNEGIE FOR 1919-1921.

By J. P. Ault.

The magnetic-survey vessel, *Carnegie*, after having been out of commission since her arrival at Washington in June 1918, has been completely overhauled and put in good repair for another cruise of world-wide extent. The tentative schedule is as follows:

Tentative Schedule for Cruise VI of the Carnegie, 1919-1921.

Port of Departure	Date of Departure	Port of Arrival	Date of Arrival	Av. Run per Day	Distance between Ports	Prospective Days at Sea	Prospective Days in Port
	1919		1919	Miles	Miles		
Washington	Oct. 8	Dakar	Nov. 9	120	3,800	32	15
			1920				
Dakar	Nov. 24	Buenos Aires	Jan. 27	100	6,400	64	20
	1920						
Buenos Aires	Feb. 16	St. Helena	Apr. 3	120	5,600	47	10
St. Helena	Apr. 13	Cape Town	May 9	120	3,100	26	25
Cape Town	June 3	Aden	July 26	120	6,400	53	25
Aden	Aug. 20	Perth	Oct. 21	120	7,500	62	30
Perth	Nov. 20	Lyttelton	Dec. 16	140	3,600	26	20
	1921		1921				
Lyttelton	Jan. 5	Papeete	Jan. 27	120	2,600	22	15
Papeete	Feb. 11	Fanning I.	Feb. 23	120	1,500	12	5
Fanning I.	Feb. 28	Honolulu	Apr. 10	120	4,900	41	25
Honolulu	May 5	Samoa	July 4	120	7,200	60	25
Samoa	July 29	Colon	Oct. 11	120	8,800	74	15
Colon	Oct. 26	Washington	Nov. 20	100	2,500	25	
				Totals:	63,900	544	230

For the first six months, as will be seen from the schedule, she will be cruising mainly in the South Atlantic Ocean where the completion of her work in 1917 was unsafe during the war. Thence, after extending the work in the Indian Ocean, carried out on the *Carnegie* in 1911, she will make such cruises in the Pacific Ocean as are designed not only to cover large areas not magnetically surveyed, but also to determine by intersection of previous tracks of the *Carnegie* and of her predecessor, the *Galilee*, the changes ever going on in the Earth's magnetism. These changes, of course, will also be determined in the other oceans traversed, at the points of intersection of the tracks of the prospective cruise with those of previous cruises of the *Carnegie*.

Her scientific and sailing personnel is as follows: J. P. Ault, in command; H. F. Johnston, magnetician, second in command; Russell Pemberton, surgeon and observer; A. Thomson, H. R. Grummann, and R. R. Mills, observers; A. Erickson, first watch-officer; C. E. Leyer, engineer; L. Miehle, second watch-officer; C. Strom, boatswain; 2 cooks; 1 mechanic; 8 seamen; and 2 cabin-boys. The observational work will pertain to terrestrial magnetism, atmospheric electricity, meteorology, and allied subjects.

LETTERS TO EDITOR

AURORAL LIGHTS, AUGUST 25, 1919, OBSERVED AT THE YERKES OBSERVATORY.

On 1919 August 25 before $10^h\ 0^m$, 90th Meridian Time, there was a low auroral arch in the north. This was not bright nor active. At $11^h\ 10^m$ this arch was faint, but in the low east, south of the Pleiades, a large bright auroral light appeared in the form of an irregular cloud-like mass several degrees wide and 10° in length (horizontally). Above this was a similar but fainter mass. The bright mass rapidly increased in size and broke into irregular masses, and a vacant space appeared in the middle of it. From this vacancy, as a center, there soon radiated broken strips and masses all over the east. The star α Ceti occupied the center of this vacuity at $11^h\ 40^m$. These masses were changing in form and brightness—but not fluctuating in the ordinary sense. This condition lasted for a short time. At $12^h\ 0^m$ it had more or less disappeared, or rather, had drifted northward as a low broad mass of light extending between the Pleiades and Capella, brighter toward the Pleiades, and as far as Polaris. At $12^h\ 15^m$ it had disappeared entirely and did not appear again. Throughout all this the low auroral arch in the north remained dim and quiet, but at $12^h\ 35^m$ this arch was strong and somewhat active, but nothing remained of the disturbance in the east.

During this phenomenon there was no corresponding aurora in the west, as sometimes occurs. From the star α Ceti I obtain the following for the position of the center of the vacancy, or center from which the auroral strips and masses radiated.

$11^h\ 40^m$, Altitude 12°.1, Azimuth, south of east, 6°.0.

Though the appearance of masses of auroral light in the low east is not uncommon, this one was the most remarkable I have seen, especially in its being the center of radiation, analogous to the auroral crown that sometimes is seen near the zenith. There were no actual streamers connected with it, but there was an unmistakable center of arrangement for the masses and strips of light at the position indicated and which was free of matter. This vacancy was roughly 8°x10°, with the longer part horizontal.

The impression given me, and this has occurred a number of times during my auroral observations, was that the auroral light in the east was entirely independent of the aurora in the north; as if two independent sources of auroral activity were at work and in no way connected.

All the times given in this letter are $6^h\ 0^m$ slow of Greenwich Mean Time.

E. E. Barnard.

Yerkes Observatory, Williams Bay, Wisconsin.

Table Showing the Magnetic Character for the Year 1918.

Dates	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Mean
January	0.1	0.2	1.0	0.9	1.0	1.0	0.4	0.1	0.2	0.7	0.2	1.3	1.0	0.9	0.9	0.4	0.1	0.1	0.0	0.3	0.9	0.4	0.1	0.7	0.5	0.4	0.7	0.4	1.4	1.8	1.6	0.63
February	1.2	1.0	0.2	0.2	1.3	1.3	8.0	0.1	0.8	1.1	1.2	1.9	1.4	1.1	1.3	1.1	0.5	0.1	0.1	0.5	0.7	0.0	1.1	0.8	0.0	0.1	0.6	1.1				0.78
March	0.6	0.7	1.1	0.6	0.1	0.1	1.1	2.0	0.9	1.1	1.1	1.1	0.2	0.4	1.5	1.3	0.4	0.4	0.0	0.8	1.0	1.0	1.1	0.3	0.0	0.5	0.9	0.4	0.7	0.5	0.6	0.73
April	0.4	0.6	0.5	0.9	1.5	1.7	1.1	0.8	0.7	0.8	1.8	1.1	0.0	0.1	0.3	0.3	0.4	1.3	1.4	0.1	0.6	0.7	1.0	0.2	1.2	1.4	0.4	0.6	0.4	1.3		0.79
May	1.1	0.5	0.4	0.7	1.0	0.4	0.1	0.1	0.2	0.4	0.9	0.7	0.6	0.9	1.1	1.7	1.9	1.3	1.1	1.0	0.9	0.5	0.4	0.4	0.2	0.1	0.1	0.1	1.0	0.9	0.2	0.68
June	0.1	0.0	0.0	0.0	0.4	0.6	0.6	0.5	1.3	1.9	1.2	1.2	0.9	1.1	1.2	1.1	0.9	0.4	0.1	0.3	0.9	0.5	0.0	0.2	0.1	0.9	0.3	0.1	0.0	0.0		0.56
July	0.9	0.8	0.8	0.5	0.4	0.2	0.3	1.1	1.0	0.8	1.1	0.7	0.8	1.0	0.9	0.5	0.2	0.5	0.0	0.0	0.1	0.1	0.3	0.3	1.4	0.9	0.9	1.5	1.3	1.2	1.0	0.69
August	0.4	0.9	0.9	0.6	0.8	0.9	1.0	1.1	1.0	0.6	0.9	0.8	0.5	0.7	2.0	1.7	0.3	0.1	0.0	0.5	0.1	0.5	0.3	1.1	1.5	1.3	1.2	0.7	0.3	0.1	1.2	0.77
September	1.5	0.8	1.0	1.2	1.2	0.9	0.8	1.1	0.6	0.6	0.1	0.1	0.5	0.5	0.2	1.1	1.1	1.2	1.4	1.2	2.0	1.2	0.7	0.9	0.4	0.2	0.6	1.1	1.0	1.2		0.88
October	1.2	1.2	1.2	1.2	1.2	0.9	0.7	1.6	1.1	0.3	0.1	0.1	0.0	0.1	1.1	2.0	1.5	1.1	1.2	1.1	0.7	0.8	0.6	0.7	0.9	0.2	0.1	1.1	0.6	0.6	1.4	0.85
November	0.7	0.6	0.1	0.2	0.1	0.0	0.1	0.2	0.3	0.9	1.6	1.7	1.4	1.2	1.5	1.2	1.0	0.6	0.8	0.6	0.5	0.6	1.6	1.3	0.5	0.1	0.2	0.6	1.8	1.2		0.77
December	1.7	0.7	1.3	0.7	0.1	0.0	1.2	2.0	1.5	1.4	1.1	0.9	1.0	0.7	0.4	0.3	0.8	0.6	1.4	1.1	1.0	0.8	1.0	0.8	2.0	1.5	0.3	0.1	0.1	0.1	0.7	0.88

Calm Days.

January	**8, 11, 17, 18, 19**	February	**8, 19, 22, 25, 26**
March	**5, 6, 19, 24, 25**	April	**13, 14, 15, 20, 24**
May	**7, 8, 9, 26, 27**	June	**2, 3, 4, 29, 30**
July	**7, 19, 20, 21, 22**	August	**1, 18, 19, 21, 30**
September	**11, 12, 15, 25, 26**	October	**11, 12, 13, 14, 27**
November	**5, 6, 7, 26, 27**	December	**5, 6, 28, 29, 30**

Days Recommended for Reproduction.

**March 8; May 17; August 15; September 21; December 25.

*February 12; April 11; June 10; September 1; October 16; November 29; December 8.

THE MAGNETIC CHARACTER FOR THE YEAR 1918.

The annual review of the "Caractère magnétique de chaque jour" for 1918 has been drawn up in the same manner as the preceding year. Thirty-eight observatories contributed to the quarterly reviews; 34 of them sent complete data. Table II of the annual review, containing the mean character of each day and each month, the list of "calm days" and the days recommended for reproduction are reprinted on page 134. G. VAN DIJK.

MAGNETIC ELEMENTS AT POTSDAM, 1918, AND DE BILT, 1915-1917.

I beg to communicate herewith at the request of Prof. Schmidt in Potsdam the mean values of the magnetic elements at Potsdam for 1918 and at the same time the values at De Bilt for 1915-1917.

Potsdam	*D.*	*I.*	*H.*	*F.*	*X.*	*Y.*	*Z.*
	° ′	° ′	γ	γ	γ	γ	γ
1918	7 49.3W	66 30.8	18646	46788	18473	−2537	42912
De Bilt							
1915	12 12.5W	66 48.0	18481	46913	18063	−3908	43117
1916	12 2.7W	66 48.8	18461	46888	18054	−3852	43101
1917	11 53.6W	66 50.1	18443	46883	18047	−3801	43103

De Bilt, March 3, 1919.

G. VAN DIJK.

THE MAGNETIC STORM OF AUGUST 11-12, 1919 AS OBSERVED AT THE WATHEROO MAGNETIC OBSERVATORY.[1]

Our magnetograph has recently recorded a large magnetic storm which began at $6^h\ 6^m$ G. M. T., August 11. After some preliminary movements, lasting for 49 minutes, rapid oscillations of large amplitude began suddenly at $6^h\ 55^m$. At $9^h\ 25^m$ of the same day these rapid oscillations gave place to long slow movements which continued until $16^h\ 22^m$, when the rapid oscillations started again and continued until about $11^h\ 0^m$ on August 12. From this time on slow movements prevailed until the end. The disturbance ended at about $19^h\ 0^m$, August 12.

It was during the long slow movement phase that the greatest displacements occurred. The range in D was $1°\ 14'.0$, and in Z, 84.7 mm., corresponding to about 254γ. The H-spot passed off the sheet at the bottom, and the range was certainly greater than 180 mm., or 378γ.

On the night of August 11 an aurora was seen in South Australia, and, according to a letter received from the Deputy Postmaster General at Perth there were serious disturbances of the telegraph lines throughout the State. W. F. WALLIS.

Watheroo, West Australia, August 24, 1919.

[1]Latitude 30° 20′ S; longitude, 116° 01′ E.

THE MAGNETIC STORM OF AUGUST 11-12, 1919 AS OBSERVED AT THE APIA MAGNETIC OBSERVATORY, SAMOA.

[From a blue print transmitted to the Journal by Dr. G. Angenheister, the observer-in-charge, the following information has been obtained respecting the chief characteristics of the severe magnetic storm of August 11-12—the severest registered at the Apia Magnetic Observatory since the one of September 26, 1909. All the times given refer to Greenwich civil mean time; they are to be regarded as approximate, as also the absolute value of the magnetic elements; the scalings were made by the Department of Terrestrial Magnetism.]

Declination (D). No large perturbations occurred and there was no marked "sudden commencement" near 7^h August 11. At about $7^h\ 58^m$, there is a sharp rise of a few minutes, signifying diminishing east declination (D); the value of D at this point is about 10° 14′ E. A minimum D of about 10° 02′ E is reached at about $9^h\ 53^m$ August 11. The total range in D for August 11-12 is thus about 12′.

Horizontal Intensity (H). The curve runs fairly smoothly until shortly before 6^h, August 11, a sort of preliminary wave to the main disturbance begins to develop itself, which reaches a crest (increase of H) at about $6^h\ 32^m$. H then drops about 10γ until about $6^h\ 52^m$; a sharp rise next begins which reaches a final maximum crest at about $7^h\ 16^m$. H then begins to drop again until about $7^h\ 55^m$ when once more it increases sharply, reaching its highest value at about $7^h\ 59^m$, namely, approximately, 35414γ. It then drops precipitously; at $9^h\ 25^m$ August 11, H has diminished to 34922γ and the trace thereafter leaves the sheet; H may have fallen as low as 34820γ, or even lower. At $10^h\ 38^m$ the trace returns to the sheet, H having a value of about 34925γ. H then rises and, after various fluctuations back and forth, reaches another high maximum of 35344γ at about $0^h\ 11^m$, August 12. The sharpest and biggest change in H, accordingly, occurred on August 11 from about $7^h\ 59^m$ ($H=35414\gamma$) to $9^h\ 25^m$ ($H=34922\gamma$). We thus have a change in H of about 492γ in 86 minutes or about 6γ per minute. The actual range in the values of H may have been as much as 600γ.

Vertical Intensity (Z). At about $6^h\ 55^m$ the numerical value of Z enters on an increase which at about $6^h\ 58^m$ receives a sharp acceleration, culminating in a peak at about $6^h\ 59^m$. A somewhat higher peak is reached at about $7^h\ 54^m$, Z having the approximate value of -20429γ. At about $9^h\ 57^m$, August 11, Z reaches its smallest numerical value of -20306. The total change in Z, accordingly, was about 123γ.

G. Angenheister.

Apia, Samoa, September 5, 1919.

THE MAGNETIC STORM OF AUGUST 11-12, 1911, AS OBSERVED AT THE CHELTENHAM MAGNETIC OBSERVATORY.[1]

A magnetic storm of extraordinary magnitude occurred on August 11, 1919, at the magnetic observatory of the United States Coast and Geodetic Survey, latitude 38° 44′ N. and longitude 76° 50′.5 W. It began abruptly at $1^h\ 58^m$ 75th meridian time, A. M., August 11. The first movement in declination (D), was from 6° 18′.9 W to 6° 14′.9 W, followed by a sudden change to 6° 37′ W. The recording spot left the sheet at $2^h\ 56^m$, at the value 7° 18′ W. and returned at $3^h\ 28^m$, the maximum having occurred during this interval, probably reaching 7° 38′ W.

The horizontal intensity (H) increased suddenly from 19208γ to 19308γ and at $2^h\ 17^m$ had reached its maximum of 19456γ. At $2^h\ 17^m$ the vertical intensity (Z) had decreased from 55382γ to 55330γ, and then increased 16γ. At $2^h\ 26^m$ the storm was in full progress.

From $3^h\ 15^m$ to $3^h\ 33^m$ even the H reserve-spot was off the lower edge of the paper, representing a decrease of at least 700γ from the value at the beginning of the storm. During this interval at least one, and apparently several complete swings of the H reserve-spot took place across the full width of the paper, representing changes in H of some 800γ. The H reserve-spot was again off the lower edge of the sheet from $4^h\ 24^m$ to $5^h\ 02^m$. The minima in H of course occurred when the H reserve-spot was off the paper.

The Z spot left the lower edge of the paper at $3^h\ 11^m$at $Z = 54848\gamma$, and returned at $3^h\ 24^m$; it left again at $4^h\ 20^m$ and again returned at $4^h\ 52^m$, the minima in Z occurring during these intervals.

As a whole the storm was characterized by the extreme rapidity and magnitude of the variations. Three phases are distinctly recognized. The first phase, the principal portion, extended from $1^h\ 58^m$ to 12^h, August 11; H was extremely low during this phase; Z was extremely low during the first half of this phase and averaged nearly normal during the latter half; D averaged nearly normal. The period of greatest and most rapid variations was from $3^h\ 11^m$ to 5^h. During the second phase from 12^h, August 11, to 4^h, August 12, the magnetic elements returned to their roughly approximate normal values, although the movements were still large and rapid. The minimum of $D = 5°\ 09'.0$ W. and the maximum of $Z = 55563\gamma$ occurred during this phase. During the third phase from 4^h, August 12, to the end of the storm, the magnetic elements were relatively quiescent, but still considerably disturbed as compared with a normal day. The storm terminated abruptly at $14^h\ 00^m$, August 12.

The maximum recorded ranges were: 2° 09′.0 in D; 890γ in H; and 715γ in Z.

In connection with a possible repetition of the storm at the next complete rotation of the Sun on its axis, 27 days later, September 7 and 8, were quiet days. September 6 was a disturbed day.

The storm was accompanied with a display of the Aurora Borealis.

GEO. HARTNELL,
Observer-in-Charge.

Cheltenham, Maryland.

[1]Communicated by the Superintendent of the United States Coast and Geodetic Survey

PÉRIODE MAGNÉTIQUE DE 27 JOURS.

M. le Dr. C. Chree a appliqué l'étude de plusieurs années des caractères magnétiques internationaux à l'examen de ce qu'il appelle la période de 27 jours, qui correspond à une rotation synodique du Soleil, dont la durée moyenne est 27.274 jours (Seventh Kelvin Lecture, p. 420). Nous ignorons si ce travail a été étendu davantage. Voici ce que nous avons fait en employant ce qui existe, c'est-à-dire de janvier 1906 à mars 1918, et en examinant plusieurs rotations successives. Le procédé a été comme suit:

On a d'abord choisi les 12 jours auxquels a été assigné le caractère 2.0. Puis, en partant de ces jours, les caractères ont été répartis jusqu'à 90 jours, avant et après. Cela faisait donc 181 colonnes pour chacune desquelles on a pris la moyenne.

Le même relevé a été fait pour les caractères 1.9, puis 1.8 etc., jusqu'à 1.5. Cependant, losqu' une rotation avait déjà été employée pour un caractère supérieur, elle ne servait plus. Ainsi dans la suite, 1.5—1.4—1.9—1.8—1.4, on n'a pris pour début que 1.9 (9 février 1906). Au contraire, si deux jours troublés sont séparés par un jour calme, par exemple, 1.6—0.4—1.6, 19 et 21 août 1908, chacun compte.

On groupait ainsi: (a) 2.0 seul; (b) 1.9 et 2.0; (c) 1.8—1.9 et 2.0, etc. Dès le premier groupement, les retours de la rotation synodique s'accusaient, autant que 12 cas seulement le permettaient. Ils allaient se précisant au fur et à mesure que le nombre des rotations appelées en témoignage augmentait. Peut-être aurions-nous dû arrêter aux caractères 1.7 et plus (74 cas). Cependant nous avons cherché une confirmation utile en poussant jusqu'à 1.5.

Voici la liste de dates où on trouve un maximum secondaire et à côté le *caractère* correspondant.

Table 1

2.0		2.0 et 1.9		2.0 à 1.8		2.0 à 1.7		2.0 à 1.6		2.0 à 1.5	
−90	0.86	−80	0.76	−83	0.70	−83	0.70	−83	0.69	−83	0.69
−56	0.82	−56	0.71	−52	0.72	−54	0.79	−54	0.83	−54	0.89
−27	0.75	−26	0.79	−24	0.79	−27	0.85	−27	0.88	−27	0.84
0	2.00	0	1.94	0	1.88	0	1.82	0	1.79	0	1.69
30	0.77	31	0.76	30	0.81	28	0.81	28	0.83	28	0.83
60	0.82	50	0.75	56	0.77	56	0.81	56	0.81	56	0.78
80	0.84	83	0.71	83	0.71	83	0.71	83	0.73	84	0.70

Nous ne dessinerons que le cas le plus général. Le tableau ci-dessus a cependant son enseignement. On y voit les dates se fixer aux multiples de la révolution synodique: 27, 54.5 et 82 ou aux environs.

De plus l'ordre d'importance de ces ondulations attire l'attention. Le caractère diminue de part et d'autre à mesure qu'on s'éloigne du paroxysme, mais de deux passages équidistants du milieu, celui qui précède est plus actif que celui qui suit. Cela n'est vrai pourtant qu'en général et surtout pour le premier et le second passage. Nous ignorons si quelque chose de particulier distingue dans le Soleil l'état d'une région active dans ces deux cas.

Au reste l'aspect même du graphique montre que chaque maximum de gauche est plus aigu que son symétrique de droite. Les dates sont aussi, de ce même côté, plus voisines des multiples de 27.3 jours. De l'autre côté, elles ont une tendance marquée à un certain retard.

Notre liste a utilisé 142 rotations, dont 12 pour 2.0, 19 pour 1.9, 21 pour 1.8, 22 pour 1.7, 33 pour 1.6, et 35 pour 1.5.

Table 2.

−90	.678	−60	.614	−30	.632	1	1.178	31	.702	61	.723
−89	.673	−59	.640	−29	.599	2	0.879	32	.636	62	.637
−88	.628	−58	.666	−28	.720	3	.687	33	.615	63	.658
−87	.577	−57	.605	−27	*.836*	4	.730	34	.689	64	.598
−86	.563	−56	.644	−26	.793	5	.657	35	.691	65	.610
−85	.606	−55	.724	−25	.737	6	.638	36	.645	66	.613
−84	.651	−54	*.802*	−24	.710	7	.687	37	.586	67	.591
−83	*.692*	−53	.762	−23	.694	8	.688	38	.598	68	.579
−82	.655	−52	.727	−22	.638	9	.680	39	.636	69	.632
−81	.662	−51	.671	−21	.655	10	.570	40	.595	70	.645
−80	.662	−50	.713	−20	.678	11	.546	41	.544	71	.578
−79	.662	−49	.617	−19	.670	12	.565	42	.592	72	.589
−78	.632	−48	.623	−18	.648	13	.616	43	.575	73	.587
−77	.618	−47	.674	−17	.641	14	.660	44	.620	74	.620
−76	.654	−46	.643	−16	.625	15	.617	45	.627	75	.630
−75	.680	−45	.621	−15	.597	16	.631	46	.614	76	.635
−74	.693	−44	.576	−14	.572	17	.680	47	.623	77	.636
−73	.617	−43	.585	−13	.605	18	.628	48	.635	78	.625
−72	.554	−42	.570	−12	.539	19	.689	49	.648	79	.573
−71	.540	−41	.560	−11	.575	20	.665	50	.653	80	.622
−70	.596	−40	.559	−10	.589	21	.709	51	.666	81	.637
−69	.633	−39	.604	−9	.657	22	.638	52	.685	82	.651
−68	.563	−38	.604	−8	.643	23	.609	53	.690	83	.701
−67	.549	−37	.613	−7	.639	24	.586	54	.746	84	*.704*
−66	.607	−36	.630	−6	.633	25	.595	55	.759	85	.678
−65	.584	−35	.632	−5	.641	26	.665	56	*.780*	86	.604
−64	.624	−34	.619	−4	.663	27	.770	57	.720	87	.556
−63	.644	−33	.616	−3	.584	28	*.830*	58	.703	88	.660
−62	.624	−32	.645	−2	.541	29	.804	59	.623	89	.624
−61	.634	−31	.611	−1	.833	30	.763	60	.647	90	.706

Paroxysme = 0 1.694

Les millièmes sont sans doute de trop. Les supprimer n'enlève rien à la présente note. Ils ont été calculés parce que la commission internationale donne deux décimales aux moyennes mensuelles depuis le temps où la collaboration était limitée à 15 observatoires.

Le maximum de 84, comme celui de −83, est en vérité petit et médiocrement dessiné, mais pas encore négligeable. On peut se demander s'il y a lieu d'étendre plus loin la recherche. Le travail, un peu onéreux, n'est nullement inabordable. Si nous ne l'essayons pas, c'est qu'il ne parait pas assez utile. Ce que nous croyons avoir constaté pour les douze années 1906-1917, dépend en trop de choses de la nature si variable des phénomènes solaires pour que nous songions à l'étendre comme une loi à un autre cycle de onze ans. Le passage d'une région magnétiquement active du Soleil a son écho dans l'état magnétique de la Terre, et cela plusieurs fois de suite, soit avant, soit après, le paroxysme. Ce point paraît hors de conteste. Une même région reste active bien plus longtemps que la durée des taches qui ont le plus de vitalité. Nous laisserons aux astronomes à nous dire ce qu'a de particulier une région active du passage qui accompagne ou occasionne le paroxysme magnétique.

Note. La révolution synodique du Soleil n'a pas une durée constante. Elle varie avec la distance du Soleil. La tendance des purturbations à se reproduire après une révolution synodique varie-t-elle aussi avec cette distance? Nous bornant à 30 jours avant et 30 jours après le paroxysme magnétique, nous avons tenté plusieurs groupements: les 12 mois grégoriens, les paires à la manière de von Bezold; les saisons ordinaires de trois mois; les trois saisons, hiver, équinoxes et été. L'année a aussi été divisée en quatre parties à peu près égales pendant chacune desquelles la longitude du Soleil varie de 90°. Enfin elle a fourni trois saisons: périgée, du 4 novembre au 2 mars (120°), équinoxes, du 3 mars au 1 mai (60°) et du 4 septembre au 3 novembre (60°) et apogée, du 2 mai au 3 septembre (120°).

Arrêtons nous à ce dernier arrangement. Tous laissent l'impression générale que douze ans de caractères internationeax ne sont pas suffisants. Avant le paroxysme il ne paraît pas se dessiner rien de précis. Après le paroxysme, il semblerait, dans tous les groupements, que le retour a lieu plus tôt au périgée, le contraire de ce à quoi on s'attendrait. Voici les résultats de ce dernier essai:

TABLE 4.

	Périgée	Equinoxe	Apogée		Périgée	Equinoxe	Apogée
−30	0.71	0.62	0.57	24	0.50	0.63	0.59
−29	0.58	0.63	0.56	25	0.60	0.55	0.62
−28	0.75	0.77	0.61	26	0.64	0.64	0.67
−27	*0.83*	*0.94*	*0.70*	27	0.69	0.73	*0.85*
−26	0.74	0.92	0.65	28	*0.83*	0.85	0.79
−25	0.64	0.85	0.66	29	0.82	*0.86*	0.60
−24	0.63	0.83	0.60	30	0.79	0.83	0.63

Une tentative infructueuse ne prouve rien, ni pour ni contre.

Lu-kia-pang, 6 Juin 1919. J. DE MOIDREY, S. J.

NOTES

11. Principal Magnetic Storms at Cheltenham Magnetic Observatory, April to September, 1919.[1]

Greenwich Mean Time		Range		
Beginning	Ending	Declination	Hor'l Int.	Vert'l Int.
h m	h m	′	γ	γ
Apr. 16, 13 —	Apr. 18, 8 —	28.9	168	197
May 13, 1 —	May 14, 5 —	22.0	150	137
May 21, 0 30	May 22, 5 30	31.5	268	105
Aug. 11, 6 58	Aug. 12, 19 00	2° 09.0[2]	890[2]	715[2]
Sep. 19, 1 42	Sep. 20, 8 —	49.1	174	203

12. We note with much pleasure the reappearance, after an interruption of nearly 5 years, of the journal "*Le Radium*," under the editorship of Gaston Danne, who succeeds Jacques Danne, its founder and first editor, who died on March 8, 1919.

13. *Local Disturbances in Swedish Waters.* We are in receipt of a pamphlet[3] by *Gustav S. Ljungdahl* containing a short account of simple methods used in surveying a region of local disturbance in Swedish waters about 9 km. SSE of the Havringe Light. It is at the entrance of Oxelösund's Harbor, latitude 58° 32′ N, longitude 17° 24′ E of Greenwich. A small detailed chart is inserted, showing the isogonics of the disturbed area. The declination is shown to change from 56° east declination to 59° west declination in passing from one point to another about 100 meters distant. This is said to be the most disturbed region in Swedish waters, so far as is known at the present time.—W. J. P.

14. *Personalia.* We record with regret the death of *Lord Rayleigh* on June 30, 1919, at 76 years of age, also the deaths of General *M. Rykatehew* and *W. Dubinsky* (Pawlowsk), regarding which we hope to give further particulars later. *S. Chapman* has accepted an appointment to the second chair of mathematics recently instituted at the University of Manchester, beginning fall 1919. *A. G. Ogilvie* has been appointed reader in Geography at the University of Manchester. *C. W. Hewlett*, at one time in the Department of Terrestrial Magnetism, resigned his professorship of physics in the North Carolina College for Women at Greensboro, N. C., in order to accept an appointment as assistant professor

[1]Communicated by *E. Lester Jones*, superintendent, U. S. Coast and Geodetic Survey; *Geo. Hartnell*, observer-in-charge. Lat. 38° 44′.0 N; long. 76° 50′.5 W. or 5h 07.4m W. of Greenwich.

[2]Recorded values only; traces went off sheet.

[3]Undersökning av missvisningen i ett jordmagnetiskt störingsområde. *Tidskrift för elementär matematik, fysik och kemi*, Stockholm, Årg. 2, 1918 (1-8).

of physics at the University of Iowa. *L. A. Bauer* returned to Washington August 18 after a trip of somewhat over five months to England, Liberia (eclipse observations at Cape Palmas, May 29), and Brussels, where as one of the United States delegates he attended the meetings of the International Research Council and of the International Geodetic and Geophysical Union, July 18-30; July 3-9 he also attended at London, as the representative of the United States Weather Bureau, the preliminary conference of directors of government weather bureaus of allied and neutral countries, called by Sir Napier Shaw.

15. *Lines of Equal Magnetic Declination for Western Europe, July 1, 1919.* This chart was prepared by the Department of Terrestrial Magnetism in October, 1918 for the use of the American Expeditionary Force, in response to a cable request from staff headquarters. The lines of equal magnetic declination are given for every 20′ and cover the region of Western Europe between the parallels of latitude 48°.5 to 51°.5 N and the meridians 1° to 9° E; they are based on all the information, both as to distribution and secular change, available to the Department at the time from various sources. *The extreme western isogonic should read 13° 20′ W instead of 13° 10′ W.* The present average annual change is given as 9′, west declination decreasing.

16. *Isomagnetic Charts for Western Canada, 1917.0.* These charts, issued by the Topographical Surveys Branch (E. Deville, Surveyor General) of the Department of the Interior, Ottawa, Canada, in 1919, comprise the following: (1) Lines of equal magnetic declination and of equal annual change in western Canada for 1917.0; (2) Lines of equal magnetic inclination in western Canada for 1917.0 and of equal annual change between 1912 and 1917; (3) Lines of equal magnetic horizontal intensity in western Canada for 1917.0 and of equal annual change between 1912 and 1917. Each chart is 30x42 cm. and applies to the part of Canada west of the 90th meridian. They were prepared by W. H. Herbert, B. Sc., magnetician, on the uniform scale of 100 miles to the inch. They are based upon observations made by the Topographic Surveys Branch, the Dominion Meteorological Service, the Carnegie Institution of Washington, the Dominion Observatory, the U. S. Coast and Geodetic Survey, Sir John H. Lefroy, etc., at over 10,000 stations for declination and at over 900 stations each for inclination and horizontal intensity.

17. *New Australian Magnetic Observatory at Toolangi.* The Government Astronomer, *J. M. Baldwin*, under date, South Yarra, Melbourne, August 15, 1919, writes as follows: "The new magnetic observatory at Toolangi is now completed, and there I believe we shall be free from any disturbance from electric traction for many years. The nearest point on the railway is 8 miles away, and I see no likelihood of any extension nearer to the new station. The building is of wood, with heavy insulation, and follows very closely the general scheme of the magnetic buildings of the United States Coast and Geodetic Survey. The instruments are of the Eschenhagen type. Malthoid has been used for roofing. At the end of last month I set up and adjusted the instruments, so that the new observatory has been in operation since August 1, 1919. The approximate scale values are: For D, 1′ per mm.; for H, 3.7γ per mm.; for Z, 5γ per mm. It is a great relief to me to have the new station built; I had almost given up hope when the money was granted, and after that the building was pushed on as quickly as possible. I am keeping on the Melbourne records for a few months yet, for the purpose of comparison, and the absolute observations are still taken

here, but later on I hope to have a small building at Toolangi for the absolute work, and to have readings taken there regularly. At present I am trying to get additional assistance so that a start may be made on these magnetic curves, but I have no idea as to whether this assistance will be granted or not."

18. *Observations during Solar Eclipse May 29, 1919.* Magnetic and allied observations, made in response to the appeal published in the Journal of last March, have already been received from the following observatories: Agincourt and Meanook (Canada), Antipolo (Philippines), Apia (Samoa), Bulawayo (Rhodesia), Buitenzorg (Java), Coimbra (Portugal), De Bilt (Holland), Dehra Dun (India), Lukiapang (China), Pilar (Argentina), Ponta Delgada (Azores), Rude Skov (Denmark), Tortosa (Spain), and Valencia (Ireland). The stations of the Department of Terrestrial Magnetism were at Cape Palmas (Liberia), Sobral (Brazil), both of which were in the belt of totality, also at Campo (Cameroun), Huayao (Peru), Puerto Deseado (Argentina), and Watheroo (Western Australia). The magnetic characterization supplied by Dr. Chree for the Kew Observatory was practically zero for each of the three days May 28, 29 and 30. The conditions were accordingly ideal for determining a possible eclipse magnetic effect. The publication of the various reports will be begun in the next issue. In the meanwhile we desire to express our sincere appreciation of the hearty coöperation received and of the promptness with which the respective observatory directors and observers have transmitted their data.

RECENT PUBLICATIONS

A. Terrestrial and Cosmical Magnetism.

Agincourt and Meanook Observatories. Results of observations at the Canadian Magnetical Observatories, Agincourt and Meanook. The year 1916. Prepared by W. E. W. Jackson under the supervision of Sir Frederic Stupart. Ottawa, J. de Labroquerie Taché, 1919 (42 with 13 curves). 29 cm.

Antipolo Observatory. Hourly results of the observations made at the Magnetic Observatory of Antipolo, near Manila, P. I., during the calendar year 1912. (Part IV of the annual report of the Weather Bureau for the year 1912). Manila, Bureau of Printing, 1918 (47). 29 cm.

Bauer, L. A. Brief statement of the results obtained at Cape Palmas, Liberia, during the solar eclipse of May 29, 1919. Observatory, London, v. 42, No. 542, August, 1919 (299-300).

Chapman, S. The solar and lunar diurnal variations of terrestrial magnetism. London, Phil. Trans, R. Soc., A, v. 218, 1919 (1-118).

Chree, C. Magnetic storms. (Lecture before the Institution of Electrical Engineers, London, May 1, 1919.) Abstr. Elect., London, v. 82, No. 22, May 30, 1919 (621-622).

Chree, C. The magnetic storm of August 11-12, 1919. Nature, London, v. 103, No. 2600, August 28, 1919 (505-506).

Coimbra. Observações meteorológicas, magnéticas e sísmicas feitas no Observatório Meteorológico de Coimbra no ano de 1918. Volume LVII. Coimbra, Imprensa da Universidade, 1919 (viii+165). 36 cm.

Commission Internationale de Magnétisme Terrestre. Caractère magnétique de chaque jour des mois janvier-mars, avril-juin, juillet-septembre 1918. De Bilt, Inst. météor. royal des Pays-Bas, 1918, 1919. 32 cm.

Cortie, A. L. The magnetic storm of August 11-12, 1919. Nature, London, v. 103, No. 2599, August 21, 1919 (483).

Dodge, G. B. Magnetic results, 1918. Toronto, J. R. Astr. Soc. Can., v. 13, No. 5, May-June, 1919 (233-235). [Results of magnetic observations at field stations in Canada.]

Greenwich Observatory. Report of the Astronomer Royal of the work done at the Royal Observatory during the year ended on May 10, 1919. Abstr. Nature, London, v. 103, No. 2590, June 19, 1919 (313-314). [The mean values of the magnetic elements for 1918 and the three previous years are given.]

Hale, G. E., and others. The magnetic polarity of sun-spots. Astroph. J., Chicago, Ill., v. 49, No. 3, April, 1919 (137-152).

Hongkong, Royal Observatory. Report of the Director of the Royal Observatory, Hongkong, for the year 1918. (T. F. Claxton, Director.) Hongkong, Noronha & Co., Govt. Printers, 1919, 20 pp. 24 cm.

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Mauritius. Annual report of the officer-in-charge of the Royal Alfred Observatory for the year 1917. (M. Koenig, Officer-in-Charge.) Mauritius, Govt. Press, 1918 (4). 34 cm.

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Terrestrial Magnetism
and
Atmospheric Electricity

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PROCEDURE AT THE MAGNETIC OBSERVATORIES OF THE UNITED STATES COAST AND GEODETIC SURVEY.[1]

BY DANIEL L. HAZARD.

In *Nature* for March 20, 1919, Dr. Charles Chree, under the title of "New Procedure at American Magnetic Observatories," reviewed the publications of the results of observations made at the United States Coast and Geodetic Survey magnetic observatories at Sitka and Honolulu for 1915 and 1916 and called attention to some changes in procedure and to the need of more information regarding certain details of the methods employed. As the questions raised must be settled before there can be that uniformity in the methods of reduction and publication which is essential to the most advantageous use of magnetic observatory results, it is well to give in some detail the considerations which led the Coast and Geodetic Survey to adopt at its five observatories the practices now in use.

Up to the end of 1914 each hourly value of declination (D), horizontal intensity (H), and vertical intensity (Z) in the monthly tabulations represented the momentary value of the quantity for the specified hour, *local mean time.* This was in accordance with the general practice at the time the observatories were established, a practice adopted before continuous photographic registration came into use, when eye readings were made once an hour, and when attention was paid mainly to the local features of the variations of the Earth's magnetism. This method has the disadvantages that only a very small portion of the observational data is utilized, undue weight is given to the portion which happens to occur at the arbitrarily selected time, and the results at one station cannot be compared in detail with those at another, par-

[1]Communicated by the Superintendent of the United States Coast and Geodetic Survey.

ticularly at the time of a disturbance, because the use of local mean time renders the tabulated values non-simultaneous.

The desirability of utilizing the whole or at any rate a larger part of the data was recognized in this Bureau soon after the work of reduction and publication began, and experiments were made with a polar planimeter as a means of determining the average value for a period of an hour. The time and labor involved was found to be prohibitive, however, and it was not until attention was called to the new reading scale devised at the Potsdam observatory that a change in methods became feasible. With a scale of this type it is possible to determine the average ordinate for a period of an hour without a material increase in the time and labor involved as compared with the old method.

The special term-day observations made in connection with the German Antarctic Expendition of 1902-3 and other similar international co-operative work at magnetic observatories to secure data for special investigations for the whole Earth emphasized the importance of greater uniformity in observatory methods so that the published results could be more readily used for such investigations. The subject was discussed[2] at the Berlin meeting of the Commission on Terrestrial Magnetism of the International Meteorological Committee in 1910, but no conclusions were reached, and the committee appointed to submit recommendations to the Commission at its next meeting apparently had not come to an agreement at the time of the outbreak of the war.

When the Coast and Geodetic Survey decided to use the average ordinate for an hour in deriving the hourly values, the time was opportune for changing from local mean time to standard meridian mean time, as there seemed to be no question as to the desirability of that step. At that time Potsdam, Wilhelmshaven, Munich, and Samoa were the only observatories, so far as could be told from the available publications, which had changed from local to standard meridian time in the tabulation of their results, and as the prime object of the change was to secure uniformity, it was decided to follow in effect the practice at those observatories, but make the 24 hourly values at our observatories cover the 24-hour period from 0^h to 24^h of the selected standard meridian, so that the first hourly value would be based on the average ordinate for the interval 0^h to 1^h and would correspond approximately to 0^h 30^m. As the results will still be used primarily for the study of variations

[2]See *Terr. Mag.*, vol. 15, 1910, pp. 190-192.

which are a function of local mean time, it was decided to use for each observatory the nearest standard meridian in fixing the limits of the tabular day, so that the reduction to local mean time will be as small as possible.

The question will no doubt be raised whether it would not be better to secure complete uniformity by using Greenwich mean time for all observatories. In answer to this, it may be said that the greater part of the irregularities in the solar-diurnal variation occur during the daylight-hours and it might prevent a complete discussion of certain problems, such as the non-cyclic change, if the tabular day began and ended in the portion of the solar day during which the more pronounced features of the diurnal variation occur, as would be the case for an observatory differing as much as 8 hours in longitude from Greenwich. Of course, for observatories in England or Western Europe, this question would not arise.

With the results for 1911, the Coast and Geodetic Survey began publishing for each month hourly values and diurnal variation tables for the five quiet days, Greenwich mean time, selected by the Executive Bureau of the Commission on Terrestrial Magnetism of the International Meteorological Committee, the form of publication agreeing with the directions contained in the circular letter sent out by the president and secretary of the Commission, supplemented by more detailed information furnished by the secretary in response to a letter of inquiry. These directions stated that, in order to reduce the additional work to a minimum, it would suffice for all practical purposes to use the value for the nearest hour of local mean time instead of the corresponding hour Greenwich mean time. The hourly means for the five selected days, uncorrected for non-cyclic change, are given on the bottom line of each monthly tabulation, the manner of deriving them being explained in the publication of the results for 1911 and 1912, but not repeated in subsequent publications. It would no doubt be an improvement to show in the table itself where the Greenwich day begins and ends and this will be introduced in future.

The directions provided that either the results should be corrected for non-cyclic change or else 25 hourly values should be given, so that allowance could be made for it. In the publication of the results for 1911 and 1912, 25 hourly values were given in the diurnal-variation tables, but in later publications, in deriving these tables, an approximate correction for non-cyclic change was applied, on the assumption that the change is uniformly distributed over the 24 hours, although the investigations of Steiner

indicate that such is not the case. The following method was employed:

The correction was based on the multiple of 24 nearest to the difference between the values for 0^h and 24^h. One half of this quantity was applied to the first and twenty-fourth hourly values with opposite signs and the corrections for the intervening hours decreased uniformly so that the zero correction fell between 13^h and 14^h. In this way the mean of the 24 hourly values was not affected by the application of the corrections. For example, if in the case of D the value for 24^h was $0'.40$ greater than the one for 0^h, a correction of $-0'.23$ was applied to the twenty-fourth hour and one of $+0'.23$ to the first hour and the corrections for the intervening hours decreased successively by $0'.02$ so that the correction for 13^h became $+0'.01$ and for 14^h, $-0'.01$. In the case of H and Z the unit involved was 0.1γ instead of $0'.01$.

In the case of the hourly means for all days and for ten selected days, and the derived diurnal-variation tables, no correction for non-cyclic change has been applied, but an attempt has been made to eliminate the effect when selecting the ten days by avoiding days of marked non-cyclic change, such as are apt to occur immediately after a severe magnetic disturbance. Until the character of the non-cyclic change has been more definitely determined and a uniform method of correcting for it has been adopted, it is believed that the uncorrected values, rather than the more or less artificially-corrected ones, can be used to better advantage by anyone engaged on special investigations.

There is another practice in the reduction of the results of the magnetic observatories of the Coast and Geodetic Survey which is open to criticism. This is the derivation of the normal diurnal-variation tables from ten selected days rather than from all the days of a month. This practice was adopted after careful consideration, in the conviction that for a study of the systematic portion of the variations of the Earth's magnetism an effort should be made to eliminate the irregular features, particularly the severe disturbances. It was believed that the use of as many as ten days would in large measure avoid an undue effect on the mean of abnormally quiet days, and similar results of arbitrary selection, so that for a study of such questions as the seasonal change of the diurnal variation, its change during the sun-spot cycle, and a comparison of results at different observatories, a homogeneous mass of data would be provided even though the same ten days were not used at all observatories. Where only five days are used, even though the days are adopted internationally, there is the danger that abnormal conditions may be present on one or more of the slected days which might lead to erroneous conclusions. This and the question of deriving diurnal-variation tables for days of large disturbance merits the early attention of the Section of Terrestrial Magnetism and Electricity of the International Geodetic and Geophysical Union.

PROCEDURE AT THE MAGNETIC OBSERVATORIES OF THE CARNEGIE INSTITUTION OF WASHINGTON.

By Louis A. Bauer.

The magnetic observatory established by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, near Watheroo, Western Australia, to be known as the "Watheroo Magnetic Observatory," has been in operation since January 1, 1919. The observatory buildings were constructed and the instruments were installed under the direction of an experienced magnetician, Mr. W. F. Wallis, for many years in charge of various magnetic observatories of the United States Coast and Geodetic Survey. After three years' strenuous work, Mr. Wallis returns to Washington to assume duties at the laboratory of the Department of Terrestrial Magnetism. In November, 1919, Mr. Edward Kidson, at one time an assistant at the Christchurch Magnetic Observatory and for many years observer in the Department of Terrestrial Magnetism, both on land and sea duty, assumed charge of the Watheroo Magnetic Observatory. It is intended ultimately to include in the program, besides the magnetic work, also atmospheric electricity, earth-currents and allied observations. Mr. W. C. Parkinson is the chief assistant at this observatory. The elevation of the observatory above sea-level is about 800 feet. The buildings were designed by Mr. J. A. Fleming, in accordance with the Department's general plans.

During the present year, the construction of another magnetic observatory has been undertaken, this time under the direction of Dr. H. M. W. Edmonds, an experienced magnetician, formerly in the employ of the Coast and Geodetic Survey and since 1910 engaged on land and sea duty in the Department of Terrestrial Magnetism. This second observatory is located near Chupaca, Peru, about 8 miles west of the railroad station, Huancayo, and about 125 miles east of Lima; its elevation above sea-level is about 11,000 feet. Its complete program will likewise include terrestrial magnetism, atmospheric electricity, earth-currents and allied observations. The magnetographs will, it is hoped, be in operation sometime in 1920; in connection with the solar eclipse of May 29, 1919, they were temporarily in operation in an adobe house during the period May 25-June 12, 1919.

There is a possibility that with the gradual reduction in the magnetic-survey work, additional magnetic observatories will be

established at carefully-selected sites. The same policy in the establishment of these new observatories will be carried out as that followed in the conduct of our world-wide magnetic survey work. Quoting from my annual report[1] for 1918, pages 242 and 245:

"The general aim of the work is to investigate such problems of world-wide interest as relate to the magnetic and electric condition of the Earth and its atmosphere, not specifically the subject of inquiry of any one country, but of international concern and benefit. The prime purpose, therefore, of this Department is not to *supplant* any existing organization, but rather to *supplement*, in the most effective manner possible, the work now being done, and to enter only upon such investigations as lie beyond the power and scope of the countries and persons actively interested in terrestrial magnetism and atmospheric electricity."

In locating our observatories, the first duty was to assist in supplying the recognized deficiency of magnetic observatories in the southern hemisphere. The approximate geographic positions and present magnetic elements for the two observatories, Watheroo and Huancayo, are:

Observatory	Latitude	Longitude	Elevation above Sea-Level	Declination	Inclination	Hor. Intensity
	° ′	° ′		°	°	c.g.s.
Watheroo	30 18 S	115 53 E	700 feet	4.4W	63.7 S	.251
Huancayo	12 03 S	75 21W	11,000 feet	8.3 E	0.2 S	.298

Questions next arise as to the methods of procedure at our observatories, both as regards observations and their reductions and publication, in order to carry out effectively the expressed intent just quoted.

It is believed that an observatory should make accessible in published form, and with fair promptness, as much as possible of all that it seeks to observe, and not content itself with the publication of limited data, selected for a particular object or investigation. The time, care, and expense involved in the proper operation of a magnetic observatory place a moral responsibility upon the institution under whose auspices the observatory is conducted to make possible the fullest use of the acquired observational data for international investigations. If that moral obligation, either for lack of funds or personnel, cannot be met it would, no doubt,

[1]*Cf. Terr. Mag.*, vol. 9, 1904, p. 2.

be better for science to discontinue the observatory and make the meager means it enjoyed available at some other place. However, many reasons, traditional, administrative, and otherwise, make radical means of concentration of resources at a small number of scientifically-selected places impracticable. When our counsel has been sought, we have generally advised against the establishment of any new magnetic observatory unless those interested had ample assurance of being able to meet successfully the scientific demands of to-day.

When one must decide as to what data to publish and in what form, he naturally will examine first the observatory publications which contain the *magnetic data in full*, viz., for each day and each hour in the year, and seek to harmonize, as far as possible, the publications of his observatory with the majority.

At the meeting of the Commission on Terrestrial Magnetism and Atmospheric Electricity of the International Meteorological Committee, held at Innsbruck in 1905, the following resolution[2] was passed:

> The Magnetic Commission solicits the Directors' Conference to seek to bring into effect that observatories, equipped with self-registering instruments, publish, in place of the momentary hourly ordinates, the mean values for hourly intervals, Greenwich mean civil time.

The proposer of this resolution, Dr. Adolf Schmidt, explained[3] that the mean ordinates should be taken for the 60-minute interval between the whole hours Greenwich time, thus from 0^h-1^h, 1^h-2^h, etc. As far as known at present, the following magnetic observatories have adopted this procedure: Potsdam, Wilhelmshaven, Munich, Samoa, and the five of the United States Coast and Geodetic Survey, viz., Vieques, Cheltenham, Tucson, Sitka, and Honolulu. The latter five, instead of beginning the tabulations for the Greenwich interval 0^h-1^h, begin them with the nearest 15° meridian time. Thus the first mean 60-minute ordinate would be for Vieques ($\lambda = 4^h\ 22^m$ W) from 0^h—1^h, 60th M. T. West, or 4^h—5^h, G. M. T.; for Cheltenham ($\lambda = 5^h\ 07^m$ W) from 0^h—1^h, 75 M. T. West, or 5^h—6^h G. M. T.; for Tucson ($\lambda = 7^h\ 23^m$ W) from 0^h—1^h, 105th M. T. West, or 7^h—8^h, G. M. T.; Sitka ($\lambda = 9^h\ 01^m$ W) from 0^h—1^h, 135th M. T. West, or 9^h—10^h, G. M. T.; for Honolulu ($\lambda = 10^h\ 32^m$ W) from 0^h—1^h, 165 M. T. West, or 11^h—12^h G. M. T.

[2] *Cf. Terr. Mag.*, vol. 10, 1905, p. 198.

[3] *Cf.* footnote 2.

Over fourteen years have passed since the Innsbruck resolution recommending that the Greenwich day be made the basis of the new daily tabulation of the magnetic elements. The fact that the Greenwich day has been adopted by so few observatories and, indeed, has not been adopted by any British magnetic observatory outside of Great Britain, though the directors of some of these observatories were present at Innsbruck, may appear as conclusive that the proposal of the universal adoption of the Greenwich day in terrestrial magnetism has not met with favor. Doubtless every one is agreed as to its being in general preferable to publish a mean ordinate of a 60-minute interval rather than the momentary, more or less sporadic, ordinate at any arbitrarily-selected instant of time, as, for example, local hourly ordinates. The points at issue are:

a. Shall the Greenwich local day be used for the daily tabulations at magnetic observatories all over the globe?
b. Will all the varied purposes of investigations in terrestrial magnetism be better served by the adoption at each observatory of the local day corresponding to the nearest standard (15°) meridian, instead of the Greenwich day?
c. Shall the mean ordinate of the first 60-minute interval center around the first half-hour, i. e., shall the interval be from 0^h-1^h, standard time?
d. Shall the mean ordinate of the first 60-minute interval center around the first hour, i. e., shall the interval be from $0^h\ 30^m$-$1^h\ 30^m$, standard time?

We have decided tentatively in favor of (*b*) and (*c*) until some recommendation has been made by the International Section of Terrestrial Magnetism and Electricity. Hence, a local standard day is adopted at each observatory which begins and ends within less than a half hour of the true local day and the tabulations are closed within the day more effectively than was ever the case when it was arbitrarily decided in former times to begin the momentary hourly scalings at *one hour after the beginning of the true local day*. It is not deemed well to lay too much emphasis at present upon such a question as the elimination of the so-called non-cyclic change, for there is no international agreement as yet with regard to the proper and most effective method of its treatment; and, as has been admitted, these changes "are generally in part of instrumental origin." The highly important question is the adequate elimination in the daily means of the major part of the variations more or less cyclic during the solar day. The tabulated

hourly quantities will furthermore be strictly comparable, as to absolute time, with similar data at other observatories. Thus both local and international needs may be adequately served.

Accordingly, at Watheroo ($\lambda = 7^h\ 44^m$ E), the first mean ordinate will be for the interval 0^h-1^h, 120th M. T. East, or 16^h-17^h G. M. T. of preceding day; for Huancayo ($\lambda = 5^h\ 01^m$ W), it will be for 0^h-1^h, 75th M. T. West, or 5^h-6^h G. M. T. Thus with these two observatories, and the nine already mentioned, the Innsbruck resolution will be followed in effect at 11 observatories, encircling the globe and following practically the same procedure with regard to the hourly tabulations.

However, in order to furnish to those observatory directors who prefer mean 60-minute ordinates beginning with the interval $0^h\ 30^m$-$1^h\ 30^m$, G. M. T., for limited number of days, as for example, the so-termed international five quiet days each month, these data will likewise be given in our publications.

It has furthermore been decided, in accordance with the principle to keep observational means and manipulations as simple as possible, to register at our observatories, as is done at the vast majority of observatories, changes in declination (D), and in horizontal intensity (H), and in vertical intensity (Z) instead of changes in the three rectangular intensity components (X, Y, Z), all of which are subject to temperature changes. In our experience it has been found very helpful to have at least one magnetograph-record (D) not affected by temperature changes, and so immediately utilizable.

It may also be pointed out that for the 11 observatories mentioned the reductions are made on the basis of practically the same magnetic standards. The Coast and Geodetic Survey, after an examination of the results of comparisons of standards, made chiefly by the Department of Terrestrial Magnetism, reached the decision, independently, to adopt the Department's provisional international standards as sufficiently accurate for all practical purposes. In Volume II of "Researches of Department of Terrestrial Magnetism," page 278, Table *C*, it was shown that the Potsdam standards adopted by Potsdam, Wilhelmshaven, Munich, and Samoa were in practical agreement with the provisional "I. M. S." standards. That others have also been favorably impressed with the practical maintenance of our standards as shown by the exhibits of comparisons in all parts of the globe with the instruments constructed in our shop, may possibly be evidenced by the further fact that we have recently received requests, made independently, from six different countries for instruments after our patterns.

Another matter to receive the greatest care at our observatories will be the accurate time-determination of special features, as for example the so-called "sudden magnetic disturbances."

DESCRIPTION OF GLASS MAGNETOGRAM SCALE USED BY THE DEPARTMENT OF TERRESTRIAL MAGNETISM.

By J. A. Fleming.

To facilitate obtaining the mean ordinate of a 60-minute interval on the magnetograms obtained at the magnetic observatories of the Department of Terrestrial Magnetism, scales have been constructed in the Department's shops somewhat similar to the type introduced by the Potsdam Magnetic Observatory[1] and as used by the United States Coast and Geodetic Survey.[2] The only difference in our glass scale from the Potsdam one arises from the fact that the Potsdam type makes use of a double scale, the actual mean ordinate in millimeters being obtained from the sum of two readings, whereas we scale the mean ordinate in millimeters direct.

The scale is a piece of plate glass 12.5 cm. wide by 20 cm. long, on which are ruled two sets of lines at right angles to each other. The vertical lines parallel to the long sides are 20 mm. apart, corresponding to the distance between hour-breaks on the Eschenhagen magnetograms, there being however for direct scaling of ordinates an extra vertical line half-way between the vertical lines inclosing the right-hand 20 mm. of the scale. The horizontal lines parallel to the short sides are 10 mm. apart. The first space at the bottom is subdivided to millimeters by short horizontal lines midway between the vertical lines. (See Fig. 1.)

A reading is made by laying the scale on the magnetogram with the ruled surface next to the paper, the horizontal lines parallel to the base line, the vertical lines crossing the base line at the hour-marks, and the space divided to millimeters including the base line. The scale is then moved up or down until one of the horizontal lines is set for the average ordinate for a portion of the curve included between two adjacent vertical lines. With a little practice this can be done readily and with surprising accuracy (except in cases of great disturbance) by making equal the areas, above and below the horizontal line, inclosed by the horizontal line, the

[1]Schmidt, Adolf. Ergebnisse der magnetischen Beobachtungen in Potsdam im Jahre 1905; Berlin, 1908, p. 31.

[2]Hazard, D. L. Results of observations made at the United States Coast and Geodetic Survey magnetic observatory at Cheltenham, Maryland, 1915 and 1916; Washington, 1918, pp. 5-6.

curve, and the two vertical lines. The number of whole centimeters of the ordinate is read at the end of this horizontal line, and the fraction of a centimeter is read to tenths of a millimeter in the space subdivided to millimeters in which the base line is included.

The scale is made wide enough to cover the space of four hours so that four ordinates can be read with only such lateral shifting of the scale as may be required to allow for slight irregularities in the distance between hour marks. In the case of great disturbance it may be necessary to subdivide an hour and make separate readings for the subdivisions to get the desired accuracy.

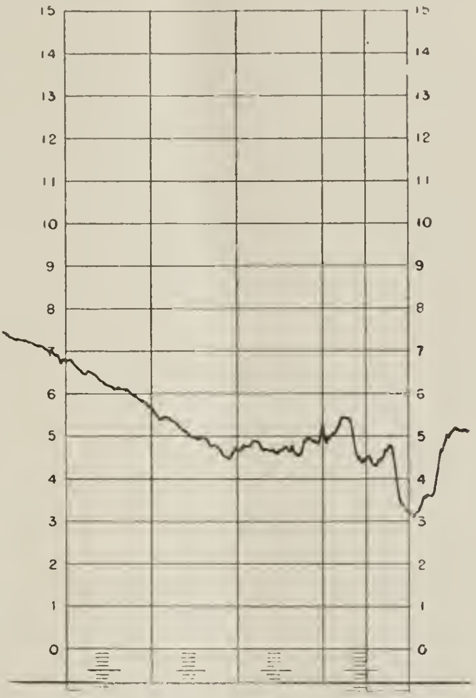

FIG. 1.—Diagram to Show Use of Scale.

The following suggestions, resulting from the experience at the United States Coast and Geodetic Survey observatories, were courteously offered by the superintendent of that survey: We have found it convenient to have one 10-millimeter space below the subdivided one, to obviate the necessity of inverting the scale where both plus and minus ordinates in excess of 10mm occur. One of our observers has found it convenient to use a drawing board and T-square in connection with this form of scale. With the magnetogram placed on the board with the base-lines parallel to the front edge, the T-square can be used as a guide to prevent lateral motion when sliding the scale up and down. For reading maximum and minimum values and ordinates at specified time, we have found it very convenient to use a celluloid scale (glass would be better), graduated to millimeters, with a line at right angles through the zero graduated in millimeters for 20 millimeters in both directions from the zero. With this scale the time can be read when the scale is in position for reading the ordinate.

DEPARTMENT OF TERRESTRIAL MAGNETISM,
CARNEGIE INSTITUTION OF WASHINGTON.

CONCERNING PROCEDURE AT MAGNETIC OBSERVATORIES.

By C. Chree, Sc.D., LL.D., F.R.S.

If I rightly follow Mr. Hazard (pages 145-148), the diurnal inequalities published of late years at the observatories of the United States Coast and Geodetic Survey for the five quiet days a month are derived from 24-hour periods which commence at 0^h G. M. T. of the international quiet days; also an approximate correction has been applied for non-cyclic change. This is so far satisfactory. But I venture to express a hope that an exact, not an approximate, non-cyclic correction may be applied in future, and that it will be extended to all diurnal inequalities.

For those who have no fondness for mental arithmetic, I would recommend the use of a table of non-cyclic corrections. Using a table, it is just as easy to apply the exact correction at each hour to the nearest 0.01 or 0.1, as the case may be, as it is to apply the approximate correction described by Mr. Hazard. The use of zonal time instead of L. M. T. is obviously advantageous for international term days. It has always been the practice for such purposes to use G. M. T. at all the British magnetic observatories. It undoubtedly facilitates the intercomparison of curves. When diurnal inequalities are analyzed in Fourier series, there are advantages in referring the phase angles to local time. But the difference between the phase angles calculated for Local and Greenwich time is constant, being determined by the difference of longitude. Thus the phase angles referred to local time can be derived at once from those calculated using Greenwich or Zonal time.

It has always seemed to me obvious *a priori* that on an individual quiet day the non-cyclic change is unlikely to be a linear function of the time. The quiet day may be an isolated one, or one of a series, but in either case the condition of quietness is seldom uniform throughout the 24 hours. If the non-cyclic effect is a consequence of previous disturbance, it will naturally diminish as the time, since the disturbance increases. If it is an antecedent of disturbance, it will presumably alter as the critical time approaches. But I have not seen any satisfactory way of deciding how the non-cyclic effect actually comes in. The problem is complicated by the fact that the regular diurnal variation appears to

be a function of the amount of disturbance present. But this is no argument for omitting a non-cyclic correction. One is really compelled to apply one for consistency's sake, because a diurnal inequality that is not periodic in 24 hours is a contradiction in terms. The only method of correction which has a reasonable chance of universal acceptance is that generally followed, which assumes the non-cyclic contribution to come in at a uniform rate. This assumption, it should be noticed, really applies not to individual days, but to the mean of all the days from which the inequality in question is derived. The assumption is presumably correct for the contribution to the non-cyclic effect from the secular change, and to that from the annual variation, if there is one. It should also, unless in exceptionally bad cases, be sufficiently exact for the fictitious effects of instrumental origin, which are known to all who have had much experience of magnetographs. These instrumental effects, in not a few cases, lead to a drift in base-line values so large as to render it expedient to vary the accepted base-line value throughout the month. One great advantage of printing 25 hourly values, answering to hours 0 to 24, is that it enables these changes of base value to be clearly shown, and does not leave the user of the volume entirely at the mercy of those who drew up the tables.

As to the method of measuring the curves, taking means from 60-minute intervals reduces greatly "accidental" features which arise from irregular disturbances, and probably on the whole it is the best plan when curves can be measured in only one way. It has been in use for some time at Eskdalemuir, and has recently been introduced at Kew Observatory for current declination-curve measurements, in place of the smoothing process employed formerly. The smoothing process was the more economical of time, and on days of "character" 0 it gives results in extremely good agreement with those got with the mean scale. But on disturbed days the smoothing process is somewhat too arbitrary, and may introduce an undesirable personal element. In very highly disturbed days, I am afraid, considerable uncertainty is inevitable, whatever plan is adopted. A mean-value scale has been in use at Kew for nine or ten years for the measurement of electrograms, and it is found necessary occasionally to enter the hourly value as *z*, to signify that the oscillations are too large and rapid for the satisfactory estimate of a mean value. During magnetic storms such as that of August 11-12, 1919, I am afraid a similar difficulty will present

itself in the measurement of magnetic curves at stations in high latitudes. The mean-value scales in use at Kew seem very similar to that described by Mr. J. A. Fleming. (See this issue, page 154.)

All the advantages do not lie with 60-minute mean values. For instance, a surveyor who is not prepared to go on reading his instruments for a whole hour at a time, may prefer to have observatory values of declination answering to exact hours, or means from a much shorter interval than 60 minutes. Again, if one had at one's disposal a large number of years' curves, a diurnal inequality based on readings taken exactly at the hour, or on means from 5 or 10 minutes centering at the hour, might have distinct advantages so far as the calculation of the Fourier coefficients is concerned. The 60-minute means round off sharp peaks, irrespective of whether they are accidental features or not. They tend to give too small amplitudes for the Fourier waves, especially those of shorter period.

As to whether the center of the 60-minute interval should fall at exact hours G. M. T., or at the half hours, there is, I regret to find, a difference of opinion. Those who prefer the half hours would do something to remove the objections I feel, if they showed clearly where changes are introduced in the base-line value used throughout the month and gave the size of these changes, so as to enable an estimate to be made of the non-cyclic changes, which otherwise may be wholly obscured. If there were no such thing as drift in instruments, or natural non-cyclic changes, there would be more to be said for what I should expect many people to consider an undesirable innovation. For certain elements, e. g., duration of sunshine or amount of rain, I agree that 60-minute intervals terminated by exact hours G. M. T. have marked advantages; but in other cases, including temperature, barometric pressure and the magnetic elements, I think the balance of advantage lies with 60-minute intervals centering at the hour.

While I think that non-cyclic corrections should be applied in all cases to hourly means before these are used for the calculation of diurnal inequalities, I consider it important that full particulars should be given of these corrections, because they undoubtedly represent an element of uncertainty, especially when they are large.

Kew Observatory, *December 3, 1919.*

REMARKS ON MAGNETOGRAM-SCALINGS AND INTERNATIONAL MAGNETIC DATA.

By Adolf Schmidt.

I note that in recently published results of the magnetic observatories under the direction of the United States Coast and Geodetic Survey the procedure has been adopted to tabulate the mean ordinate for Greenwich hourly intervals, centering around the half hour, the same as at Potsdam. The non-cyclic effect may be determined from the adopted procedure just as satisfactorily as from that advanced by Dr. Chree,[1] namely, by obtaining the value at the beginning and end of the day from the two adjacent hourly means. There is no ground for assuming that it is necessary for this purpose to adopt simply the mean of one hourly interval.

As to the adoption of the Greenwich *day* for the daily tabulations, I put less weight upon this matter. To prefer not to use the Greenwich day but instead some day corresponding to the nearest 15-degree meridian time, is natural from practical considerations. If anyone prefers to use, nevertheless, the Greenwich day (not simply the Greenwich hours which is the matter of chief importance), this may always be done; it will only be necessary to divide up the hourly series at some other point. However, I would suggest that at the observatories where the Greenwich day is not generally adopted, those data for which strict simultaneity over the Earth is actually requisite be also computed for the Greenwich day and published along with the other results; this suggestion would entail only a small amount of additional work. Such desired data are:

a. The daily means, which for the study of the "after disturbance," or the so-called "Nachstoerung," must be strictly simultaneous. (I mean that two daily means should be formed, one for the adopted local standard day and one for the Greenwich day.)

b. The data for the diurnal variation from the international five quiet days for each month. The chief value of these data lies therein that they pertain everywhere to the same time-interval. If, on the contrary, the time-interval is different at each station then the mean daily variations as formed for each station cannot be associated with one another. It may happen in fact that at one station a part of the day, according to the adopted local time, would be greatly disturbed. But even if this should not happen to be the case, then the data for the hours according to different standard times would not strictly correspond, since even on various quiet days the diurnal variation is often appreciably,

[1] *Nature*, March 20, 1919.

especially with regard to the amplitude, different. Therefore in the circular (Item No. 2) of the Executive Bureau[1] of November 1, 1913, special emphasis was placed upon this point. In the formation of the monthly means of the diurnal variation from all days, the considerations just stated have less weight. If it does not happen that just at the beginning or end of the adopted local day the course of the diurnal variation is not greatly disturbed, then a shifting of the terminal points by some hours (at the most twelve) does not matter much.

It may also not be superfluous to recall that the "magnetic character numbers" likewise pertain to the Greenwich day.

I do not regard it desirable that everywhere the components X, Y, Z, be registered except at the chief observatories, and even there D and H should also be registered. I should have preferred that at the Seddin Observatory D, H, and Z be registered, had we not continued the registration of these elements at Potsdam. Furthermore, at Seddin there is also installed a D-unifilar, which, to be sure, while only used for occasional registrations, is always available for such purposes.

Experience has shown that no such complicated device for obtaining the mean hourly ordinate as that of Messerschmitt and Lutz, to obtain the desired accuracy is requisite. It is truly remarkable how accurately and readily even the mean ordinate for the entire day can be found with the simple device used at Potsdam.

Potsdam, *November 1, 1919.*

EDITORIAL COMMENTS.

We hope that others will be induced to express their opinions in future issues of this Journal, regarding the points raised in the foregoing articles by Messrs. Hazard, Bauer, Chree, and Schmidt. Unless those directly concerned record their opinions when important resolutions are proposed at meetings of international bodies, either at the time, if they happen to be present, or if not, within a reasonable time thereafter in some publication, they would appear to be under moral obligation, at least, to carry out a resolution when passed. Take, for example, the Innsbruck resolution of 1905, here under discussion, there apparently was no dissentient vote recorded at the time, nor do we recall any subsequent printed discussion or criticism, although the Potsdam magnetic observatory proceeded to carry the resolution into effect, beginning with its 1905 observations.

In our "Editorial Review," published in this Journal, vol. XV, attention was called to the various resolutions which had been passed from time to time by the Magnetic Commission of the International Meteorological Committee. On page 197 it was suggested "that each worker in terrestrial magnetism or atmospheric electricity determine for himself just how many of these resolutions he has himself heeded in the past or is heeding now, and if there are any he is not carrying out, let him fix the cause in his own individual case."

Unless more effective means are found than in the past to put into execution matters resolved upon and unless greater readiness is shown in future to follow such resolutions, after ample opportunity has been offered for individual expression of opinion, those responsible for the conduct of magnetic and electric work necessarily lay themselves open to valid criticism.

[1] Magnetic Commission of International Meteorological Committee.

VALUES OF THE MAGNETIC ELEMENTS AT THE OBSERVATORIES OF THE UNITED STATES COAST AND GEODETIC SURVEY AT THE TIME OF THE SOLAR ECLIPSE OF MAY 29, 1919.

By D. L. Hazard.

In order to supply data for a comparison of the magnetic condition of the Earth within and outside the eclipse belt at the time of the solar eclipse of May 29, 1919, values of the declination, horizontal intensity and vertical intensity have been derived from the magnetograms of the five magnetic observatories of the United States Coast and Geodetic Survey for every five minutes of the period from 10^h to $16^h\ 30^m$ Greenwich mean time. In reading the ordinates a graphical integration was made, so that a tabular value is approximately the average value for the 5-minute period of which the tabular time is in the middle.

Tables are given showing the diurnal variation of the magnetic elements for selected quiet days: May 29 to June 7 for Porto Rico, Cheltenham and Sitka; May 28–30, June 1–7 for Tucson; May 27–31 for declination and vertical intensity, and May 8, 16, 29, 30, 31 for horizontal intensity for Honolulu. A plus sign indicates eastward deflection of the north end of the needle, or increasing intensity.

It should be noted that inasmuch as our monthly tabulations of hourly values are based on the average ordinate for hourly periods beginning at midnight of the standard meridian time which falls nearest to the meridian of the observatory, the tabular values refer approximately to the middle of these hourly periods, that is, the first value in the tables applies to $0^h\ 30^m$, the second to $1^h\ 30^m$ and so on.

Table I.—*Location of the observatories and mean values of the magnetic elements, May, 1919.*

Observatory	State	Latitude (North)	Longitude (West)	*Approximate magnetic elements*			
				D		H	Z
		° ′	° ′	° ′		γ	γ
Vieques.....	Porto Rico..	18 08.8	65 26.9	3 39	W	27900	34820
Cheltenham..	Maryland...	38 44.0	76 50.5	6 14	W	19170	55400
Tucson......	Arizona....	32 14.8	110 50.1	13 48	E	26930	45660
Sitka.......	Alaska.....	57 03.0	135 20.1	30 26	E	15580	55790
Honolulu....	Hawaii.....	21 19.2	158 03.8	9 50	E	28860	23750

TABLE 2.—*Magnetograph values of declination on May 29, 1919.*

G. M. T.		Porto Rico	Cheltenham	Tucson	Sitka	Honolulu
h	m	° ′	° ′	° ′	° ′	° ′
10	00	3 37.6 W	6 10.8 W	13 47.7 E	30 23.0 E	9 49.7 E
	05	37.4	10.6	47.8	23.1	49.7
	10	37.2	10.5	47.8	23.1	49.7
	15	37.1	10.3	47.8	23.2	49.8
	20	37.0	10.1	47.9	23.3	49.8
	25	36.8	09.8	47.9	23.4	49.8
	30	36.6	09.7	48.0	23.5	49.9
	35	36.5	09.6	48.0	23.6	49.9
	40	36.3	09.5	48.0	23.6	49.9
	45	36.2	09.4	48.1	23.6	49.9
	50	36.2	09.4	48.1	23.6	49.9
	55	36.1	09.4	48.2	23.6	49.9
11	00	36.1	09.3	48.2	23.7	50.0
	05	35.9	08.9	48.3	23.8	50.0
	10	35.7	08.8	48.3	23.9	50.0
	15	35.5	08.6	48.4	24.0	50.0
	20	35.4	08.4	48.4	24.0	50.1
	25	35.3	08.2	48.5	24.1	50.1
	30	35.2	08.0	48.5	24.2	50.1
	35	35.2	07.9	48.6	24.5	50.1
	40	35.2	07.6	48.6	24.3	50.1
	45	35.2	07.6	48.7	24.5	50.2
	50	35.2	07.6	48.7	24.8	50.2
	55	35.2	07.6	48.7	24.8	50.2
12	00	35.2	07.6	48.8	24.7	50.3
	05	35.2	07.4	48.8	24.7	50.3
	10	35.2	07.2	48.9	24.9	50.3
	15	35.3	06.9	48.9	25.0	50.3
	20	35.3	06.7	48.9	25.2	50.3
	25	35.3	06.7	48.9	24.7	50.3
	30	35.4	06.7	49.0	24.7	50.2
	35	35.5	06.6	49.3	25.0	50.3
	40	35.7	06.6	49.6	25.1	50.3
	45	35.9	06.7	49.7	25.7	50.4
	50	36.0	07.1	49.8	26.0	50.4
	55	36.1	07.3	49.9	26.3	50.4
13	00	36.2	07.5	50.1	26.5	50.4
	05	36.3	07.2	50.3	27.2	50.5
	10	36.5	07.5	....	28.1	50.6
	15	36.7	07.9	50.5	28.7	50.6
	20	36.7	08.2	50.5	28.3	50.6
	25	36.8	07.7	50.9	28.4	50.6
	30	37.0	07.9	51.0	28.8	50.6
	35	37.1	08.1	51.1	29.1	50.7
	40	37.2	08.2	51.3	29.2	50.7
	45	37.4	08.5	51.5	29.6	50.8
	50	37.6	08.7	51.7	29.6	50.8
	55	37.7	08.9	51.8	29.8	50.8
14	00	37.8	09.1	51.9	30.0	50.8
	05	38.0	09.1	51.9	30.1	50.9
	10	38.2	09.3	52.0	30.1	50.9
	15	38.4	10.0	51.9	30.1	51.0
	20	38.5	10.2	52.0	30.1	51.0
	25	38.7	10.1	52.2	30.2	51.0
	30	38.9	10.5	52.1	30.3	51.0
	35	39.1	10.7	52.1	30.4	51.0
	40	39.2	10.9	52.1	30.5	51.1
	45	39.3	11.2	52.3	30.8	51.2
	50	39.4	11.4	52.3	31.0	51.2
	55	39.5	11.7	52.1	30.4	51.2

TABLE 2.—*Magnetograph values of declination on May 29, 1919*—Continued.

G. M. T.	Porto Rico	Cheltenham	Tucson	Sitka	Honolulu
h m	° ′	° ′	° ′	° ′	° ′
15 00	3 39.7 W	6 12.0 W	13 51.9 E	30 30.6 E	9 51.2 E
05	39.9	12.5	51.9	30.8	51.3
10	40.0	12.9	51.9	31.1	51.3
15	40.1	13.4	51.9	31.4	51.3
20	40.2	13.5	51.9	31.8	51.3
25	40.3	14.1	51.8	32.2	51.4
30	40.3	14.5	51.7	32.6	51.5
35	40.4	14.9	51.5	33.0	51.6
40	40.4	15.2	51.3	33.0	51.7
45	40.5	15.3	51.1	33.1	51.8
50	40.6	15.5	50.9	33.2	52.0
55	40.7	15.7	50.8	33.1	52.2
16 00	40.9	16.1	50.7	33.2	52.3
05	41.0	16.5	50.5	33.2	52.4
10	41.1	16.9	50.3	33.2	52.5
15	41.1	17.5	50.0	33.2	52.6
20	41.2	18.3	49.8	33.6	52.9
25	41.2	18.6	49.5	34.1	53.2
30	41.3	19.0	49.4	34.1	53.3

TABLE 3.—*Diurnal variation of magnetic declination for May-June, 1919.*

Hour Std. Mer.	Porto Rico 60°	Cheltenham 75°	Tucson 105°	Sitka 135°	Honolulu 165°
h h	′	′	′	′	′
0–1	−0.1	0.0	+0.2	−1.1	0.0
1–2	0.0	+0.7	+0.2	−1.2	0.0
2–3	+0.3	+1.0	+0.4	−0.3	+0.3
3–4	+0.6	+1.4	+0.7	+0.9	+0.7
4–5	+0.9	+2.4	+1.4	+3.0	+1.3
5–6	+1.5	+4.7	+2.3	+5.4	+3.1
6–7	+3.1	+6.4	+4.1	+7.4	+4.1
7–8	+4.0	+7.1	+5.2	+9.4	+3.3
8–9	+3.5	+5.6	+4.7	+9.3	+1.5
9–10	+2.0	+3.7	+2.4	+6.9	−0.5
10–11	+0.4	−0.3	−0.6	+2.8	−2.0
11–12	−0.8	−3.6	−3.3	−0.9	−2.8
12–13	−1.7	−6.0	−4.0	−3.2	−2.6
13–14	−2.5	−6.2	−4.0	−5.2	−2.2
14–15	−2.5	−5.8	−3.3	−6.5	−1.2
15–16	−2.2	−4.3	−2.5	−7.2	−0.4
16–17	−1.4	−2.5	−1.2	−6.3	−0.2
17–18	−0.7	−1.3	−0.6	−5.1	−0.2
18–19	−1.0	−0.7	−0.4	−2.6	−0.2
19–20	−1.0	−0.8	−0.7	−1.0	−0.3
20–21	−0.9	−0.6	−0.7	−0.4	−0.5
21–22	−0.7	−0.5	−0.1	−1.0	−0.5
22–23	−0.4	−0.6	−0.2	−1.8	−0.4
23–24	−0.2	+0.1	−0.1	−1.1	−0.2

TABLE 4.—*Magnetograph values of horizontal intensity on May 29, 1919.*

G. M. T.		Porto Rico	Cheltenham	Tucson	Sitka	Honolulu
h	m	γ	γ	γ	γ	γ
10	00	27910	19174	26935	15591	28870
	05	910	174	935	591	870
	10	910	174	935	591	870
	15	910	174	935	591	870
	20	910	174	935	591	869
	25	910	175	935	591	870
	30	910	175	935	591	870
	35	910	176	936	591	870
	40	909	176	936	591	869
	45	909	176	936	591	869
	50	909	176	936	591	869
	55	909	176	936	591	869
11	00	909	176	936	591	869
	05	909	176	936	591	869
	10	909	177	937	591	870
	15	909	177	937	591	869
	20	909	176	937	591	869
	25	909	176	937	591	870
	30	909	176	938	592	870
	35	910	176	939	594	871
	40	909	176	940	594	871
	45	909	176	940	594	871
	50	910	175	940	594	871
	55	909	174	940	594	871
12	00	909	174	941	595	871
	05	909	173	941	595	871
	10	909	172	941	596	871
	15	909	172	941	595	871
	20	909	171	941	595	871
	25	909	169	942	596	871
	30	910	166	942	595	871
	35	910	166	942	595	871
	40	911	164	943	593	870
	45	911	164	943	593	870
	50	911	163	943	594	870
	55	911	162	943	594	870
13	00	912	161	943	593	871
	05	913	161	943	593	871
	10	914	162	....	595	871
	15	915	163	944	599	871
	20	915	160	944	601	871
	25	916	159	943	597	871
	30	916	160	944	598	871
	35	916	160	944	599	871
	40	916	160	943	598	872
	45	916	159	943	599	871
	50	915	159	942	598	871
	55	914	159	943	599	871
14	00	915	159	943	599	871
	05	915	159	942	599	871
	10	915	157	941	598	871
	15	915	156	941	598	871
	20	916	157	941	598	871
	25	916	157	940	598	872
	30	917	157	940	596	872
	35	918	156	940	594	871
	40	919	156	939	596	872
	45	920	156	939	595	872
	50	921	156	938	594	873
	55	921	155	938	592	873

TABLE 4.—*Magnetograph values of horizontal intensity, May 29, 1919.*—Cont'd.

G. M. T.	Porto Rico	Cheltenham	Tucson	Sitka	Honolulu
h m	γ	γ	γ	γ	γ
15 00	27921	19154	26937	15590	28873
05	921	154	937	588	873
10	921	153	936	587	872
15	922	154	935	587	872
20	922	154	935	587	872
25	922	154	934	587	872
30	922	156	934	587	872
35	922	157	933	587	872
40	922	157	932	586	872
45	922	157	932	584	872
50	922	157	931	580	873
55	922	157	931	578	873
16 00	921	157	931	578	873
05	920	158	931	577	874
10	919	159	932	575	874
15	918	160	934	576	874
20	918	161	936	578	875
25	918	164	937	580	875
30	918	166	938	581	875

TABLE 5.—*Diurnal variation of horizontal intensity for May-June, 1919.*

Hour Std. Mer.	Porto Rico 60°	Cheltenham 75°	Tucson 105°	Sitka 135°	Honolulu 165°
h h	γ	γ	γ	γ	γ
0–1	−7	−2	−5	+5	−5
1–2	−9	−2	−4	+6	−4
2–3	−10	−2	−2	+9	−4
3–4	−10	−2	0	+13	−4
4–5	−9	−1	+2	+15	−2
5–6	−8	+1	+6	+15	+1
6–7	−4	−2	+6	+14	+3
7–8	+2	−13	+2	+11	+5
8–9	+8	−24	+1	+3	+6
9–10	+14	−32	+4	−5	+7
10–11	+16	−23	+6	−12	+9
11–12	+20	−7	+8	−16	+14
12–13	+19	+8	+9	−18	+17
13–14	+15	+19	+8	−18	+15
14–15	−9	+23	+3	−12	+9
15–16	0	+21	−2	−11	+3
16–17	−6	+16	−7	−8	−6
17–18	−7	+7	−8	0	−12
18–19	−6	+5	−6	−2	−12
19–20	−5	+2	−3	0	−12
20–21	−6	+2	−6	0	−10
21–22	−5	+4	−5	+2	−9
22–23	−5	+2	−5	+5	−6
23–24	−6	+1	−4	+5	−2

TABLE 6.—*Magnetograph values of vertical intensity on May 29, 1919.*

G. M. T.		Porto Rico	Cheltenham	Tucson	Sitka	Honolulu
h	m	γ	γ	γ	γ	γ
10	00	34829	55414	45663	55805	23742
	05	830	414	663	804	743
	10	829	413	663	804	743
	15	829	413	663	803	743
	20	828	413	663	803	743
	25	828	413	663	802	743
	30	827	413	663	803	744
	35	827	414	663	802	744
	40	827	414	663	802	744
	45	827	414	663	802	744
	50	827	414	663	802	745
	55	827	414	663	802	745
11	00	827	414	663	802	745
	05	827	414	663	801	745
	10	827	414	663	801	746
	15	826	414	663	801	746
	20	826	413	663	801	746
	25	826	413	663	801	746
	30	827	412	663	801	746
	35	826	413	664	801	746
	40	826	413	664	802	746
	45	826	413	664	802	746
	50	827	413	664	802	746
	55	827	413	664	803	746
12	00	826	412	664	804	746
	05	826	411	664	803	746
	10	826	411	664	804	746
	15	827	410	664	803	746
	20	827	410	665	803	746
	25	826	410	665	804	746
	30	825	410	665	804	746
	35	824	410	665	804	746
	40	824	410	665	803	746
	45	824	410	665	802	746
	50	825	409	665	802	746
	55	825	408	666	802	746
13	00	825	408	666	802	746
	05	824	407	667	801	747
	10	825	406	....	801	747
	15	826	406	668	801	747
	20	826	406	668	802	747
	25	824	405	669	804	746
	30	825	406	669	804	746
	35	825	405	669	803	747
	40	825	405	668	803	747
	45	826	405	668	802	746
	50	826	404	668	802	746
	55	826	405	667	802	746
14	00	826	405	667	803	747
	05	827	404	667	802	747
	10	827	404	667	802	747
	15	827	403	667	802	746
	20	829	403	666	801	747
	25	829	403	666	801	747
	30	830	403	665	800	747
	35	830	404	665	800	746
	40	830	404	665	800	746
	45	830	404	665	800	747
	50	830	403	664	800	747
	55	831	403	663	799	747

TABLE 6.—*Magnetograph values of vertical intensity on May 29, 1919.*—Continued.

G. M. T.	Porto Rico	Cheltenham	Tucson	Sitka	Honolulu
h m	γ	γ	γ	γ	γ
15 00	34830	55402	45663	55798	23747
05	830	403	663	797	747
10	830	402	662	796	747
15	829	402	662	796	747
20	829	401	661	795	747
25	829	400	661	794	748
30	829	400	661	794	749
35	829	400	660	793	749
40	828	400	659	793	750
45	828	400	658	793	750
50	827	400	658	792	751
55	827	400	657	792	751
16 00	827	401	656	792	752
05	827	401	655	791	753
10	827	402	654	789	753
15	827	403	654	789	754
20	827	403	654	789	755
25	827	403	652	788	756
30	828	403	652	789	757

TABLE 7.—*Diurnal variation of vertical intensity, May-June, 1919.*

Hour Std. Mer.	Porto Rico 60°	Cheltenham 75°	Tucson 105°	Sitka 135°	Honolulu 165°
h h	γ	γ	γ	γ	γ
0–1	0	0	+4	+5	+4
1–2	−1	−1	+5	+3	+4
2–3	−1	+1	+5	+3	+4
3–4	−1	+1	+5	+5	+5
4–5	−1	+5	+6	+6	+8
5–6	0	+5	+7	+2	+14
6–7	−1	+3	+10	−6	+13
7–8	−3	+1	+8	−12	+5
8–9	−4	−2	+2	−15	−5
9–10	−4	−7	−7	−16	−12
10–11	−2	−10	−13	−16	−14
11–12	0	−11	−14	−15	−12
12–13	+2	−8	−13	−11	−7
13–14	+4	−5	−10	−6	−3
14–15	+4	0	−8	−2	+1
15–16	+4	+5	−5	+3	+1
16–17	+2	+7	−1	+8	0
17–18	+1	+6	+2	+12	−2
18–19	+1	+5	+3	+10	−2
19–20	0	+3	+2	+9	−2
20–21	+1	+2	+2	+8	−2
21–22	0	+1	+3	+9	−1
22–23	0	+1	+3	+9	0
23–24	0	−1	+4	+8	+2

U. S. COAST AND GEODETIC SURVEY.

WOLFER PROVISIONAL SUN-SPOT NUMBERS FOR JANUARY TO JUNE, 1919.

Communicated by G. van Dijk.

Date	Jan.	Feb.	March	April	May	June
1	32	80	79	....	49	81
2	16	....	....	51	63	104
3	....	148	65	....	89	96
4	7	147	40	104	....	118
5	....	170	....	67	113	....
6	....	....	70	63	126	134
7	29	....	74	79	109	107
8	....	119	84	....	106	87
9	77	134	66	74	117	67
10	....	116	126	....	98	88
11	110	98	108	37	83	79
12	91	82	97	24	68	92
13	....	71	....	28	67	124
14	93	55	....	41	59	117
15	72	60	....	29	66	97
16	....	....	....	13	77	125
17	....	....	73	....	106	107
18	....	....	69	18	146	111
19	....	47	53	19	158	149
20	40	43	32	16	160	142
21	39	25	26	25	128	145
22	21	29	....	33	109	153
23	....	....	28	29	91	152
24	....	45	42	....	95	101
25	....	45	43	69	61	92
26	....	57	....	61	65	....
27	....	44	56	61	52	....
28	50	56	58	....	44	116
29	50	....	51	73	24	77
30	....	....	....	79	49	55
31	....	....	66	....	60	....
Means..	52.0	79.6	63.9	47.5	87.8	108.0

MAGNETIC CHARACTER FIGURES FOR KEW OBSERVATORY, MAY 23–30, 1919.[1]

By Charles Chree.

In allotting magnetic "character" figures for De Bilt I have at no time taken much cognizance of the *V* (vertical force) curves; because here these almost never show serious disturbance unless the two other elements *D* and *H* are highly disturbed. Occasionally, when in doubt as between a 1 and a 2, I may have let the *V*-trace decide. Now the artificial disturbance in *V* renders it all the less useful for help in fixing "characters".

My normal procedure is to go first through the *D*-curves (taking 2 or 3 months' curves at a time to assist in uniformity of standard) and assign to each day the following "character" figures in ascending order of disturbance:

$$\underline{0},\quad 0,\quad \overline{0},\quad 1,\quad 1,\quad \overline{1},\quad \underline{2},\quad 2,\quad \overline{2}$$

Having completed the *D*-curves and put them aside I similarly deal with the *H*-curves.

If the figures assigned to the *D*-and *H*-curves of a day are both 0 (or $\underline{0}$) it gets a 0 without further inquiry. Similarly a 1 to both *D*- and *H*-curves would result in a 1, while a 2 or $\overline{2}$ to both curves would get a 2. This usually settles at once half the days or more. In dealing with the other days I put corresponding *D*- and *H*-curves side by side and pass judgment. Naturally a 0 in *D* and $\overline{0}$ in *H* means (nearly always) a 0, while a $\underline{1}$ and 1 similarly nearly always means a 1. Usually the trouble arises with a $\overline{0}$ from one element and a $\underline{1}$ from the other, or $\overline{1}$ in one element and $\underline{2}$ in the other. Undoubtedly, if the month is a very quiet one, 1 is allowed to smaller disturbances than it is if the month is a very disturbed one.

I had dealt with May some time ago, and when doing so was not sure of the date of the eclipse; thus my choice was as unprejudiced, I think, as usual.

The "character" figures allotted were as follows:

Date in May	23	24	25	26	27	28	29	30
From D............	$\overline{0}$	$\underline{2}$	1	1	1	0	0	0
" H............	1	2	1	1	$\underline{1}$	$\overline{0}$	$\overline{0}$	$\overline{0}$
Finally accepted.....	1	2	1	1	1	0	0	0

[1] Information solicited by Dr. Bauer in connection with the solar eclipse of May 29, 1919.

On a very disturbed month the 24th might have got a 1, as the disturbance in D was decidedly on the small side fo a 2, while ther disturbance in H was not of a very irregular type. There was no great disturbance on any day in V. Still on both the 24th and 26th the diurnal range was decidedly in excess of the normal. While the D-curve on the 28th was undoubtedly of "character" 0, it was not altogether of exactly the normal type. The morning rise to the maximum was distinctly arrested between 10½ and 12^h G. M. T. The D-range between 8^h and $13\frac{1}{2}^h$ on the 28th was decidedly less than on the 27th or 29th. Between these hours the 27th and 29th D-curves looked decidedly more normal than the curve of the 28th.

Accompanying this are particulars of mean hourly values of D from May 23 to May 30 inclusive. These were really deduced from a free hand pencil trace, which we have found—when drawn in our usual way—to give very nearly the same results as a mean-hourly-value scale.

Kew Observatory, *July 1, 1919.*

Declination at Kew Observatory, Richmond, Surrey, May 23-30, 1919.

[D = 14° West + tabular quantity.]

1919	0^h	1^h	2^h	3^h	4^h	5^h	6^h	7^h	8^h	9^h	10^h	11^h	12^h
	′	′	′	′	′	′	′	′	′	′	′	′	′
May 23......	40.5	40.5	39.8	40.1	39.6	37.8	36.6	36.3	37.1	39.4	41.6	43.6	46.6
24......	42.6	42.6	42.0	41.9	44.6	46.0	44.3	40.6	40.8	43.8	45.9	46.8	48.3
25......	41.9	40.1	37.7	35.6	35.6	37.5	39.9	37.6	35.7	37.5	39.9	43.2	46.6
26......	40.8	41.4	39.7	38.9	37.6	37.1	36.6	36.5	37.4	37.6	40.4	43.5	48.5
27......	39.4	39.8	42.3	42.7	46.0	45.5	38.7	35.5	34.2	34.7	36.5	41.7	45.3
28......	41.4	41.4	41.1	40.5	38.6	36.7	35.8	35.7	36.1	37.6	40.5	41.6	43.4
29......	40.8	41.1	41.6	40.9	41.4	40.4	36.6	35.0	34.9	36.7	39.5	42.9	46.6
30......	41.8	41.5	40.9	40.2	38.7	36.7	34.9	33.9	34.2	35.8	38.3	40.6	43.2

1919	13^h	14^h	15^h	16^h	17^h	18^h	19^h	20^h	21^h	22^h	23^h	24^h	Means[1]
	′	′	′	′	′	′	′	′	′	′	′	′	′
May 23..	48.9	47.3	44.7	43.6	42.3	41.2	40.7	40.9	41.4	41.5	41.8	42.6	41.50
24..	48.3	47.9	48.0	45.6	41.2	40.5	39.5	37.3	36.3	36.8	40.0	41.9	42.95
25..	49.3	50.6	49.7	47.8	44.0	43.3	42.7	42.5	41.6	41.6	41.5	40.8	41.76
26..	51.5	51.3	52.1	49.9	47.7	46.6	44.4	40.9	38.7	38.4	39.4	39.4	42.31
27..	47.0	46.7	46.3	44.3	41.7	40.7	40.6	40.9	41.2	41.6	41.8	41.4	41.55
28..	46.4	45.6	43.9	42.5	41.5	41.3	40.5	41.2	41.7	42.4	41.9	40.8	40.78
29..	48.9	49.7	48.4	45.6	43.1	41.6	42.2	42.0	41.8	41.7	41.9	41.8	41.93
30..	45.8	47.7	46.8	45.6	43.0	40.9	41.6	42.6	42.5	42.3	42.7	42.1	40.94

[1] In forming these means, the values given in the first column (0^h) were omitted.

MAGNETIC STORM OF AUGUST 11–12, 1919.

By D. L. Hazard.

A comparison of the magnetograms from four[1] of the magnetic observatories of the United States Coast and Geodetic Survey for the period of the very large magnetic disturbance of August 11–12, 1919, shows that while the storm had the same general characteristics at all of the observatories, there were very radical differences in detail. Unfortunately the motion of the magnets became so rapid at times that portions of the records were lost or rendered unintelligible, either because the spots of light passed beyond the limits of the paper or because they moved too rapidly to affect the sensitized paper or because the records of the three variometers could not be distinguished with certainty. At Cheltenham the records of the auxiliary Adie magnetograph supplied most of the gaps in the record of the Eschenhagen magnetograph and at Sitka the observer, while changing paper, noticed that a severe storm was in progress and widened the slit of the lantern, so that a good record was secured of the rapid oscillations which characterized the middle and end portions. *Greenwich mean civil time is used throughout this paper.*

General Characteristics.—After a period of small fluctuations, beginning at $18^{h}\ 40^{m}$ on August 10, and a larger disturbance lasting about an hour and a half, the storm proper began abruptly at $6^{h}\ 57^{m}$ on August 11. Then followed seven hours of irregular fluctuations of very wide range, one extreme succeeding another sometimes in a few minutes, and sometimes in half an hour or even longer. This constitutes the principal portion of the storm, when amplitude alone is considered. From 14^{h} to the end of the storm there was an almost unbroken series of fairly regular rapid oscillations, the period ranging from 2^{m} or less at the beginning to about 5^{m} at the end. There was a marked decrease of amplitude at about 9^{h} on August 12, not only in the oscillations, but also in the underlying irregular fluctuations, and a slight increase in activity about 15^{h}. At 19^{h} the oscillations and the storm itself ended as abruptly as it began and the curves immediately became as smooth as on a quiet day.

[1] The illness of the observer-in-charge of the Honolulu magnetic observatory has resulted in delay in the transmission of his records.

During the fluctuations which preceded the storm there were two series of 15 or 20 fairly regular waves of about 1mm. amplitude and 2^m period, one beginning at $0^h\,30^m$ and the other at $1^h\,35^m$.

Declination.—The initial easterly motion in declination (1′–5′) lasted about a minute and was followed by an equally abrupt but larger westerly motion. The declination continued low for about 1½ hours, and during that time the minimum (westerly extreme) occurred. Soon after 8^h an easterly motion set in and the easterly extreme was reached shortly before 10^h. At Cheltenham, however, this was a secondary phase, the actual easterly extreme not occurring until $1^h\,54^m$ on August 12.

Horizontal Intensity.—This magnetic element increased by a large amount at the beginning and continued much above normal for over an hour, the maximum occurring during this interval. Just before 8^h there was a sharp increase to a maximum (the extreme value in some cases) followed immediately by a remarkable decrease amounting in the case of Cheltenham to as much as 1000γ. The value of H (horizontal intensity) continued very low with wide fluctuations until about $16^h\,30^m$ and the minimum occurred during this period, the time and amount being indeterminate because even the reserve spots passed off the paper. The subsequent fluctuations were irregular and differed in direction and magnitude at the different observatories.

Vertical Intensity.—At Cheltenham and Sitka there was a slight increase of vertical intensity at the beginning followed almost immediately by a considerable decrease. At Tucson and Porto Rico, on the other hand, there was no preliminary "kick" and the storm began with a considerable increase lasting for half an hour or more. At all four observatories the minimum probably occurred shortly before 10^h but subsequent phases are not in good agreement.

Tables.—In the following tables are given the times of occurrence of salient points and the corresponding values for the four observatories. The plus sign signifies east declination, and the minus sign, west declination.

U. S. Coast and Geodetic Survey.

Salient Points and Corresponding Values for Magnetic Storm August 11, 1919.

Phase	Cheltenham		Porto Rico		Tucson		Sitka	
	Time	Value	Time	Value	Time	Value	Time	Value
Declination								
	h m	° ′	h m	° ′	h m	° ′	h m	° ′
Normal......	...	−6 15	...	−3 40	...	+13 48	...	+30 27
Beginning....	6 57	6 19	6 57	3 42	6 56	13 50	6 57	30 43
Reversal.....	6 58	6 15	6 58	3 41	6 57	13 52	6 58	30 48
Minimum....	8 10[1]	7 18[1]	8 02	4 06	8 15	13 30	...	29 30[6]
Maximum....	9 53	5 33	9 50	3 30	9 37	14 20	...	32 47[6]
Maximum....	1 54[9]	5 09	1 52[9]	3 31	2 13[9]	14 03	...	...
Horizontal Intensity								
		γ		γ		γ		γ
Normal......	...	19160	...	27890	...	26900	...	15580
Beginning....	6 57	19208	6 57	27925	6 56	26917	6 57	15620
Maximum....	7 10	19456	7 17	28080	7 10[5]	27110[5]	7 30	15807
Minimum....	7 51	19239	7 45	27988	...	......	9 12[7]	14757[7]
Maximum....	7 54	19489	7 59	28069	7 55[5]	27110[5]	...	....
Minimum....	9 40[2]	18440[2]	12 24	27596	9 45	26540	9 43[7]	14757[7]
Maximum....	...	.....	...	.....	...	.....	4 42[9]	16177
Vertical Intensity								
		γ		γ		γ		γ
Normal......	...	55400	...	34840	...	45600	...	55750
Beginning....	6 57	55382	6 58	34850	6 57	45600	6 56	708
Reversal......	6 58	55387	...	.....	6 59	45605	6 58	717
Minimum....	7 20	55330	...	.....	8 30	45577	7 26	495
Maximum....	7 32	55346	7 16[4]	34940[4]	8 56	45587	7 41	579
Minimum....	8 15[3]	54848[3]	9 52	34648	9 30	45558	8 10[8]	268[8]
Maximum....	1 47[9]	55563	...	.....	14 08	45635	4 32[9]	970

[1] Spot of light was off the magnetogram from 7:55 to 8:25; minimum probably 20′ to 30′ less than the tabular value.

[2] Off from 8:15 to 8:33 and again from 9:24 to 10:02; minimum probably 100γ less than the tabular value.

[3] Off from 8:10 to 8:20 and again from 9:20 to 9:52; minimum probably about 54500γ.

[4] Curve missing, because of rapid motion, from 7:55 to 8:03 and again from 16:51 to 17:24; the tabulated maximum may have been exceeded at one of these times.

[5] Off from 7:02 to 7:21 and from 7:50 to 8:03; maximum greater than tabulated values.

[6] The motion of D was very rapid between 8:00 and 9:30. The spot evidently passed off the paper in both directions and the extremes were in excess of tabular values.

[7] H reserve spot was off the paper between 9:00 and 9:15, 9:38 and 9:48, and also between 12:04 and 12:30. The minimum was no doubt much less than the tabulated value.

[8] Off from 7:50 to 8:29 and at other times later; minimum much less than tabulated value.

[9] August 12.

THE MAGNETIC STORM OF AUGUST 11–12, 1919, AT LUKIAPANG, CHINA.

There was a severe magnetic storm recorded at Lukiapang from August 11 to 13, 1919. It seems to have been more violent than the great storm of September 25, 1909, certainly the perturbations were sharper if not of greater magnitude. The storm started quite suddenly at $14^{h}\ 58^{m}$ (China Central Time) on August 11 simultaneously for the three elements, west declination decreasing, horizontal intensity increasing, and vertical intensity decreasing. The movements were so rapid that no visible trace was obtained for the horizontal intensity. There was a difference of at least 431 gammas on August 11 between $17^{h}\ 55^{m}$ and $23^{h}\ 48^{m}$. Judging from declination and vertical intensity this may have been the greatest change, in which case because of the double mirror arrangements we should not have lost anything if the paper had been sufficiently sensitive to record the rapid movements. Mr. A. C. M. Andersen, engineer in charge of the Great Northern Telegraph Co., informs us that disturbances of extraordinary strength were experienced on all their cables from the afternoon of August 11 until about 17^{h} on August 12. One of the submarine cables between Woosung and Gutzlaff (resistance 376 ohms) was earthed at one end and the current was observed at the other end through a milliammeter. The current appeared to be changing continually and even rapidly between positive and negative; it reached a maximum of more than 25 milliamperes in both directions. Unfortunately the ammeter could not register above 25 milliamperes. J. DE MOIDREY, S. J.

LUKIAPANG, CHINA, *September, 1919.*

EARTHQUAKE OF APRIL 30, 1919, AS RECORDED ON THE MAGNETOGRAM AT WATHEROO OBSERVATORY.

On examining the magnetogram for April 30, 1919, the day on which an earthquake and tidal wave swept Pan-gai, a town in one of the islands of the Tonga group, we found a distant earthquake record, the elements of which are as follows:

Element	Declination Greenwich Mean Time April 30, 1919	Horizontal Intensity Greenwich Mean Time April 30, 1919	Vertical Intensity Greenwich Mean Time April 30, 1919
	h m	h m	h m
Beginning.	7 28.5	7 28.8	7 44.7
Ending. . .	8 03.0	8 22.8	8 22.8
Maximum.	7 30.0	7 55.5	7 56.7
Max. Ampl.	. ....	3 mm.	. ....

It should be noted that the photographic sheet was removed at $8^{h}\ 22.8^{m}$, this being the usual time for changing the paper, and a new sheet was started five minutes later. There is no record of the earthquake on the second sheet. We could not determine the amplitudes of the declination and vertical-intensity vibrations because the traces were blurred owing to the movements of the magnets.

The Tonga Islands lie approximately 4,640 miles east-northeast from the Watheroo Observatory, Western Australia.

W. F. WALLIS.

SUR LES POINTS DU GLOBE OÙ IL SE PRODUIT UNE MARÉE ÉLECTRIQUE, DÉRIVÉE DE LA MARÉE OCÉANIQUE, OBSERVE-T-ON UNE MARÉE MAGNÉTIQUE?

C'est la question à laquelle j'ai voulu répondre pour Jersey, île de la Manche, Angleterre, où la marée électrique dérivée de la marée océanique a été observée pour la première fois dans le courant de l' année 1918 (*Terr. Mag.*, vol. 23, pp. 37-39 et 145-147; vol. 24, pp. 33-38). Cette marée électrique a-t-elle l'intensité suffisante pour imposer son caractère au magnétisme terrestre, à la variation diurne de la déclinaison en particulier?

Ayant ici à ma disposition les trois boussoles qui m'avaient servi en Chine, à l'observatoire de Zi-ka-wei, de 1873 à 1887, pour les mesures magnétiques en valeurs absolues, j'ai installé provisoirement le petit aimant tubulaire avec miroir comme un déclinomètre unifilaire, disposant les choses de manière que la minute de déviation de l'aimant corresponde à un écart de 1 millimètre du point lumineux sur le papier d'enregistrement.

Après deux mois d'essais j'ai cru les observations recueillies durant les trois lunaisons de juillet, août et septembre 1919, suffisantes pout laisser au moins entrevoir la solution à donner au problème proposé. Ces premiers résultats sont disposés dans le Tableau ci-dessous de manière à être facilement appréciés après quelques explications nécessaires.

Marée océanique.—Je l'ai déterminée à l'aide des 4 phases principales de chaque journée. Dans un tableau préparé les hauteurs minima et maxima de l'eau dans le port de Jersey ont été inscrites à la suite, chacune à son jour et à son heure. Le tableau rempli, il s'est trouvé quatre hauteurs inscrites sous chacune des 24 heures du jour solaire, deux basses mers et deux hautes mers, ces deux-ci comme ces deux-là à 15 jours de distance. J'en ai calculé les moyennes; leur série présente la double oscillation de la marée; les deux minima tombent aux heures qui ont vu les deux plus basses mers, et les deux maxima aux heures qui ont vu les deux plus hautes mers de la lunaison. C'est la moyenne marée dont le Tableau ci-dessous donne les écarts horaires sur la moyenne hauteur générale de l'eau dans le port. Cette hauteur moyenne, pour les trois mois étudiés, a été $5^{m}.75$. Dans les plus grandes marées, a Jersey, la variation totale de niveau est de 11 à 12 mètres.

Marée électrique et marée magnétique.—Les observations horaires du courant tellurique et de la déclinaison magnétique ont été traitées exactement de la même manière en vue de leur faire serrer le plus près possible la marée océanique. J'ai dit dans mon dernier article que les phases de la marée électrique étaient opposées à celles de la marée océanique et en avance de 1 heure et demie environ. Partant de ce fait, j'ai distribué les observations comme il suit; dans un tableau partagé en deux séries de 12 colonnes j'ai commencé par inscrire dans la première des deux parties, intitulée M,

les deux observations de chaque journée lunaire faites *une heure avant les deux basses mers*, les autres observations ont été alors inscrites à leurs rangs dans les autres colonnes. Les 24 moyennes calculées représentent la marée électrique composée répondant point pour point à la marée océanique. De même pour la marée magnétique si la déclinaison magnétique en comporte une.

JERSEY—CONCORDANCE, EN JUILLET, AOÛT ET SEPTEMBRE 1919 DES TROIS MARÉES.

Heures		Océanique	Tellurique	Magnétique	Déclin. magn. Var. diurne magn.
sol.	lun.	mètre	volt.	′	′
1	M	−1.28	+0.0028	+0.54	−2.51
2	1	−1.54	+ 13	+0.51	−2.45
3	2	−1.20	− 08	+0.28	−2.27
4	3	−0.50	− 28	−0.09	−2.31
5	4	+0.22	− 40	−0.53	−2.78
6	5	+0.92	− 43	−0.88	−3.61
7	6	+1.35	− 38	−1.06	−4.39
8	5	+1.35	− 20	−0.99	−4.48
9	4	+1.10	+ 10	−0.66	−3.42
10	3	+0.52	+ 31	−0.15	−1.14
11	2	−0.19	+ 46	+0.42	+1.88
Midi	1	−0.79	+ 48	+0.91	+4.82
13	M	−1.25	+ 38	+1.20	+6.80
14	1	−1.36	+ 19	+1.23	+7.32
15	2	−1.16	− 03	+0.98	+6.41
16	3	−0.62	− 23	+0.56	+4.61
17	4	+0.29	− 36	+0.06	+2.63
18	5	+0.97	− 39	−0.39	+1.05
19	6	+1.35	− 32	−0.68	+0.10
20	5	+1.47	− 18	−0.75	−0.39
21	4	+1.09	+ 01	−0.61	−0.72
22	3	+0.43	+ 19	−0.31	−1.16
23	2	−0.28	+ 30	+0.05	−1.74
Min.	1	−0.86	+ 34	+0.36	−2.26
Moyen niveau de l'eau ou Moyen voltage du courant tellurique.		5.75	0.0083	N	D

Les deux variations, électrique et magnétique, ont la forme générale de la marée océanique, mais leurs phases ne concordent pas avec les siennes; il y a même opposition complète pour la marée magnétique qui est en retard de deux heures environ sur la merée électrique. Cette opposition de phases des deux marées dérivées avec la marée principale est déjà difficile à justifier, mais le grand retard de la déclinaison sur le courant tellurique ne semblera-t-il pas inexplicable? Peut-on concevoir autrement qu'instantanée une influence électro-magnétique? D'autre part, comment admettre une dépendance directe du magnétisme de la terre des mouvements des eaux à sa surface?

Bien que les deux oscillations diurnes de la déclinaison que nous trouvons ici ne soient pas égales entr'elles comme le sont celles des

deux autres marées, elles diffèrent notablement de la variation diurne solaire dont l'oscillation de nuit est presque nulle, à Jersey, durant ces trois mois d'été de 1919. C'est bien la double oscillation d'une marée se développant parallèlement à la marée électrique. Son amplitude moyenne est-elle assez grande pour qu'on y voie une influence réelle de cette dernière?

On sait qu'une influence directe de la Lune sur le magnétisme terrestre a été reconnue partout où on l'a recherchée avec soin, mais partout elle s'est dévoilée très faible, l'amplitude de la variation produite s'étant trouvée au plus de 45″ (Philadelphie). Qu' avons-nous à cet égard à Jersey d'après le Tableau ci-dessus? La double oscillation de cette marée magnétique se décompose comme suit:

$$\left.\begin{array}{ll}1^{\text{er}}\text{minimum} & -1'.1\\ 2^{\text{d}}\text{ maximum} & +1'.3\end{array}\right\}2'.4 \qquad \left.\begin{array}{ll}2^{\text{d}}\text{ minimum} & -0'.8\\ 1^{\text{er}}\text{ maximum} & +0'.6\end{array}\right\}1'.4$$

$$\text{Amplitude moyenne} = 1'.9 \text{ ou } 114''$$

C'est une forte oscillation, mais il faut prendre garde que l'influence propre du Soleil n'a pas été éliminée des résultats. Si avant de distribuer les observations horaires de la déclinaison selon les heures lunaires, on en retranche l'action du Soleil qui est la moyenne variation diurne durant la lunaison, alors la marée magnétique lunaire proprement dite se décompose ainsi:

$$\left.\begin{array}{ll}1^{\text{er}}\text{ minimum} & -0'.6\\ 2^{\text{d}}\text{ maximum} & +0\ .6\end{array}\right\}1'.2 \qquad \left.\begin{array}{ll}2^{\text{d}}\text{ minimum} & -0'.3\\ 1^{\text{er}}\text{ maximum} & +0\ .3\end{array}\right\}0'.6$$

$$\text{Amplitude moyenne} = 0'.9 \text{ ou } 54''$$

Cette marée lunaire est de même forme que la marée composée et d'amplitude moitié moindre. Cette amplitude est sensiblement plus grand que la plus forte trouvée en dehors de Jersey. D'après Sabine, l'action directe de la Lune aurait donné lieu aux oscillations suivantes: 21″ à Kew, 19″ au Cap, 19″ à Toronto, 9″ à Pekin. Mes observations de 1877 à 1881 m'ont donné 14″ pour Zi-Ka-Wei (Chine). On peut donc conclure avec quelque assurance que la marée électrique dérivée de la marée océanique produit elle-meme une marée magnétique.

Il va être d'autant plus facile de vérifer cette conclusion par des observations à faire sur d'autres rivages et dans l'intérieur du continent puisque je viens de constater que l'observation du courant tellurique n'exige pas, pour électrodes en terre, deux conducteurs d'aussi grand développement que celui des deux réseaux des conduites d'eau et de gaz d'une ville; un tube de plomb de 6 mm. de diamètre, enterré sur 13 mètres de longueur à courte distance d'une plaque de cuivre rouge de 2 à 3 décimètres carrés, me fournit journellement des diagrammes qui rivalisent de détails avec l'ancien circuit. L'intensité de ces variations est en proportion de la longueur du conducteur, mais avec un galvanomètre sensible et l'emploi de shunts convenables on obtiendra toujours des courbes satisfaisantes.

MARC DECHEVRENS.

OBSERVATOIRE ST. LOUIS, *Jersey, 10 novembre 1919.*

CONCERNING THE ELECTRIC TIDE OBSERVED AT JERSEY.

The June 1919 issue of *Terrestrial Magnetism*, page 100, contains a note by Dr. Mauchly, seeking to explain the electric tide observed at Jersey by the effect of the hydrostatic pressure of the sea seeping through the shores, on the low-lying gas-pipe system of the city of St. Helier. In a letter addressed to me on November 26, 1918, the director of the Meteorological Office at London had already suggested this explanation to me in the absence of a better one. This explanation must, however, be abandoned in view of another fact which seems no less striking than the rest.

For some time I have been obtaining by means of two underground couples, very different as regards metals and length or development of surface, *absolutely similar* diagrams of the earth current both for the electric tide and for all the small or large irregularities (there remains only a slight difference of amplitude which it would be easy to eliminate). One of these couples is the old one, viz., that consisting of the pipes of the city gas and water systems. The other consists on one hand of 3 or 4 square decimeters of sheet copper right against the observatory, forming the positive electrode; on the other hand it consists of a lead pipe (it contains two copper wires, but this is of little consequence) which goes *under ground*, a distance of 13 meters, from the observatory to the thermometer hut; this is the negative electrode. The first couple has a vast development, from our hill to the sea; the second couple occupies only an insignificant space, two kilometers from the sea and 55 meters of altitude. If one could speak of an electric effect of the hydrostatic pressure of the sea, it could only be in consequence of the compression of the Earth itself.

Hence, the earth current with all its peculiarities may be captured and studied with the greatest ease, at any place, by any one who has a sensitive galvanometer which he can join to two rods of copper and lead thrust into the ground, near each other, but without touching, for I am persuaded (I am going to make experiments on this point) that this should be sufficient. But it is necessary to have a galvanometer sensitive to a thousandth of a volt at least, as will be seen.

It is necessary to recognize, in these buried metal couples, their mean potential difference of contact with the damp soil and the accidental variations which it will undergo, which have their cause outside the soil and are independent of the nature of the conductors and of their actions due to contact with the ground which they occupy. As electrodes, the copper-lead couple is more active than the iron-galvanized iron couple; the voltages are respectively, at this time 0.10 and 0.09 of a volt. But the weaker couple, that is, the one consisting of gas and water pipes, collects in its enormous extent, more than 100 times as much electric energy as the couple which is naturally stronger, but which occupies only an insignificant space. The galvanometer of the large circuit, exactly like the other, requires, in order that the traces remain on the registration paper, a shunt having a resistance of only an ohm, while with the small circuit for obtaining traces, even the most restricted, the galvanometer is shunted by a resistance of 60 ohms. (I am sending herewith a specimen of the curves registered by either system; their descriptions are written

on the back of the sheets. The paper employed for the reproductions is shorter than the original paper; it lacks at least an hour of registration at the beginning and at the end. The day commences at 8^h in the morning, in order to have in the middle of the diagrams the perturbations of the night. You will be surprised at the magnificent development of the double diurnal oscillation of our electric tides; the 11th of October is the day which the British Admiralty tables indicated for the two highest tides of the October lunation.)

Since last April I have been continuing observations of the potential of the air by means of a vane-collector (collecteur-girouette) which is better insulated than in 1912 and 1913. I found again the mean daily curves of my last memoir; particularly, 11 days in August showed at noon the maximum of the 24 hours.

MARC DECHEVRENS.

Observatoire St. Louis, Jersey, October 10, 1919.

COMMENTS ON DECHEVRENS' ELECTRIC TIDE OBSERVATIONS.

I have examined Father Dechevrens' letter of October 10, 1919, and the accompanying traces. While the evidence appears at first sight to be against the explanation which ascribes the phenomenon under discussion to electrolytic effects, this is not necessarily the case, as his small Cu-Pb system is so near to the terminals of his larger system that it could scarcely be considered outside the sphere of influence of the latter.

Since Father Dechevrens in the above letter says that the *current* in his small system is *less than 1 per cent* of that in the larger system (i. e., the one which certainly *may* show electrolytic effects due to the tide), it is by no means impossible that the current-fluctuations in the Cu-Pb system may be due to strays from the iron-galvanized iron system.

I have also had the opportunity of reading Father Dechevrens' article on the "Magnetic Tide" in the current issue of this journal. When one considers that delicate magnetometers will record disturbances due to stray currents from electric railways as much as 12 miles (20 km) distant (see *Terr. Mag.*, vol. 11, 1906, p. 53), it does not seem at all improbable that the currents observed at Jersey should produce measurable magnetic effects. That this has been found to be true does not, however, throw much light on the nature and origin of the currents. The 2-hour lag of the magnetic effect can not be discussed without detailed knowledge of local conditions.

It would be interesting and instructive to know the results of observations similar to those mentioned above, but made at points well removed from both of the pipe systems, especially from the gas-pipe system.

The lunations to which Father Dechevrens has called attention seem to indicate a definite connection with the tide. However, none of the evidence thus far published excludes the possibility of the observed effects being of electrolytic origin.

S. J. MAUCHLY.

Department of Terrestrial Magnetism, December 10, 1919.

NOTES

19. *Principal Magnetic Storms at Cheltenham Magnetic Observatory, July to September, 1919.*†

Greenwich Mean Time		Range		
Beginning	Ending	Declination	Hor'l Int.	Vert'l Int.
h m	h m	° ′	γ	γ
Aug. 11, 6 58	Aug. 12, 19 00	2 09.0*	890*	715*
Sept. 19, 1 42	Sept. 20, 8 ..	49.1	174	203

20. *Geophysical Institute at Tromφ.* According to communication from Director Th. Hesselberg, the Tromφ Geophysical Institute is now the central institution for terrestrial magnetism of the Norwegian Meteorological Institute.

21. The *Milne Seismological Observatory* formerly at Shide, in the Isle of Wight, has been *transferred to Oxford*, where the work will be continued under the direction of Prof. H. H. Turner.

22. *Personalia.* Rear-Admiral *F. C. Learmouth*, C. B., has been appointed Hydrographer of the British Navy in succession to Rear-Admiral Sir *John Parry*, retired. *R. G. K. Lempfert* and Lt. Col. *E. Gold* have been appointed assistant directors in the British Meteorological Office, the former having general oversight of observations and contributing stations, and the latter having charge of forecasting. The Royal medal has been awarded by the Royal Society to *J. H. Jeans* for his researches in applied mathematics and the Hughes medal to *Charles Chree* for his researches in terrestrial magnetism. *N. A. F. Moos* has retired from the post of directorship of the magnetic and meteorological observatories of Bombay and Alibag, India, which he has so successfully filled for many years. We understand that the future direction of these observatories will be under the director-general of observatories in India, *Gilbert T. Walker*. We must record with regret the death of Lt. Col. *B. F. E. Keeling*, Surveyor-General of Egypt, at Cairo, on September 20, 1919. For several years he was in charge of the Helwan Observatory and of magnetic survey work in Egypt. During the war he carried out survey duties in England, France, and the Eastern Mediterranean, being severely wounded in France.

23. *Corrigendum.* Vol. 24, 1919, pp. 88 and 90: The cuts for Figs. 24 and 25 should be interchanged.

24. *Nature's Jubilee Number.* The editor and the publishers of *Nature* are certainly to be congratulated upon the many articles of extreme interest in the Jubilee issue and the numerous well-deserved expressions of appreciation and good-will from all parts of the world which have appeared in subsequent issues. We likewise desire to record our good wishes for continued success and prosperity.

25. *Special Articles.* It is proposed to publish during 1920 some special articles setting forth the status of certain researches in terrestrial magnetism and terrestrial electricity in commemoration of the uninterrupted continuance of this Journal for a quarter of a century, though its financial support is dependent upon subscriptions received from persons and institutions interested in the articles published. Attention is invited to the Notice on the second page of cover. It is hoped that there will be sufficient additional subscriptions in 1920 to avoid increase in the price of subscription.

* Recorded values only. Traces off sheet.

† Communicated by E. Lester Jones, Superintendent U. S. Coast and Geodetic Survey; Geo. Hartnell, Observer in Charge. Lat., 38° 44.0′ N; Long., 76° 50.5′ or 5h 07.4m W. of Greenwich.

LIST OF RECENT PUBLICATIONS

A. Terrestrial and Cosmical Magnetism.

Meteorological Office. Hourly values from autographic records: 1915. Comprising hourly readings of terrestrial magnetism at Eskdalemuir Observatory and summaries of the results obtained in terrestrial magnetism, meteorology, and atmospheric electricity chiefly by means of self-recording instruments at the observatories of the Meteorological Office. (British Meteorological and Magnetic Year Book, 1915. Part IV.) London, Meteorological Office, 1918 (95 with 8 pls.) 31 cm.

Meteorological Office Observatories—Geophysical Journal. Daily values—solar radiation, meteorology, atmospheric electricity, terrestrial magnetism, and seismology. Units based on the C. G. S. system. Seventh year, Nos. 1–12, Jan.–Dec., 1917; Eighth year, Nos. 1–4, Jan.–Apr., 1918. London, Meteorological Office, 1918–1919, 31 cm.

Mitchell, A. Crichton. The magnetic storm of August 11-12, 1919. Nature, London, v. 103, No. 2600, August 28, 1919 (506).

Pilar, Observatório Magnético. Resultados mensuales de observaciones magnéticas hechas en el Observatório Magnético de Pilar. (F. H. Bigelow, Jefe de Sección.) Buenos Aires, Bol. Mens. Oficina Met. Nacional, año 1, 1916; año 2, 1917; año 3, No. 1, 1918. [1916-1919.] [Each issue of the monthly bulletin contains the values of declination, horizontal and vertical intensity, for the month to which it applies.]

Reeves, E. A. A transformation of the magnetic dip chart. London, Geog. J., v. 53, No. 3, March, 1919 (152–165). Comments by L. C. Bernacchi and J. W. Evans: *idem*, No. 5, May, 1919 (358, 359–360).

Rio de Janeiro. Annuario publicado pelo Observatorio Nacional do Rio de Janeiro para o anno de 1918. Anno XXXIV. Rio de Janeiro, Imprensa Nacional, 1918 (524). ·18 cm. [Contains values of the magnetic declination at Rio de Janeiro for 1918, as also tables and curve showing the magnetic declination at Rio de Janeiro from 1660 to 1910, together with a table of magnetic-declination values recently obtained at various field stations in Brazil.]

Rio de Janeiro. Annuario publicado pelo Observatorio Nacional do Rio de Janeiro para o anno de 1919. Anno XXXV. Rio de Janeiro, Imprensa Nacional, 1918 (502). 18 cm. [Contains values of the magnetic declination at Rio de Janeiro for 1919, as also tables and curve showing the magnetic declination at Rio de Janeiro from 1660 to 1910, together with a table of magnetic-declination values recently obtained at various field stations in Brazil.]

San Fernando. Anales del Instituto y Observatorio de Marina de San Fernando publicados de orden de la superioridad, por el Director Don Tomás de Azcárate. Sección 2a. Observaciones meteorológicas, magnéticas y sísmicas. Año 1914. San Fernando, 1915 (viii+165 con 2 fotogramas). 35 cm.

San Fernando. Anales del Instituto y Observatorio de Marina de San Fernando publicados de orden de la superioridad, por el Director Don Tomás de Azcárate. Sección 2a. Observaciones meteorológicas, magnéticas y sísmicas. Año 1915. San Fernando, 1916 (viii+166 con 2 fotogramas). 35 cm.

Schmidt, A. On the problem of whether the diurnal terrestrial magnetic variation on the earth's surface possesses a potential. Physik. Zs., Leipzig, v. 19, 1918 (349-355). Title: London, Q. R. Meteor. Soc., v. 45, No. 190, Apr., 1919 (188).

Stonyhurst College Observatory. Results of meteorological, magnetical and seismological observations, 1918. With report and notes of the Director, W. Sidgreaves. Blackburn, Thomas Briggs, Ltd., 1919 (xix+39). 18½ cm.

Toronto Observatory. Results of meteorological, magnetical and seismological observations 1918. Published under the direction of Sir Frederic Stupart, F. R. S. C., Director of the Meteorological Service, Canada. Toronto, Observatory Press, 1919 (51). 19½ cm.

United States Coast and Geodetic Survey. Annual report of the Superintendent, United States Coast and Geodetic Survey, to the Secretary of Commerce for the fiscal year ended June 30, 1918. Washington, D. C., U. S. Dept. Comm., Coast Geod. Surv., 1918 (133 with 37 illus.) 23 cm. [Contains general account of the magnetic work of the Coast and Geodetic Survey during the fiscal year and sketches showing the magnetic stations occupied in the United States; also progress maps showing magnetic stations occupied in United States possessions to June 30, 1918.]

B. Cosmical Electricity and Radioactivity.

Brooks, C. F. Auroral displays. Science, New York, N. Y., N. S., v. 50, No. 1286, Aug. 22, 1919 (185).

Chree, C. Electric potential gradient and atmospheric opacity at Kew Observatory. London, Proc. R. Soc., A, v. 95, 1918 (210–234).

Denning, W. F. Aurora Borealis. Observatory, London, v. 42, No. 536, Feb., 1919 (84–85).

Knoche, W. Ueber die Radioaktivität einiger Heilquellen Chiles. Valparaiso, Imprenta Victoria, 6 pp. 25 cm.

Knoche, W. Bestimmungen des Emanationsgehaltes im Wasser des Llanquihuesees (2). S.-A. Mitt. Deutsch-Chil. Bundes, Santiago, Dec., 1918, 3 pp.

Knoche, W. Ueber die Zahl der Gewitter in Chile. S.-A. Mitt. Deutsch-Chil. Bundes, Santiago, Heft Nr. 3, 12 pp. 25 cm.

NORWEGISCHES METEOROLOGISCHES INSTITUT. Jahrbuch des Norwegischen Meteorologischen Instituts für 1916. Kristiania, Gröndahl & Sön, 1917 (167). 33 cm. [Contains results of potential-gradient observations at Aas Meteorological Observatory during 1916.]

NORWEGISCHES METEOROLOGISCHES INSTITUT. Jahrbuch des Norwegischen Meteorologischen Instituts für 1917. Kristiania, Gröndahl & Sön, 1918 (170). 33 cm. [Contains results of potential-gradient observations at Aas Meteorological Observatory during 1917.]

STÖRMER, C. Sur un problème relatif au mouvement des corpuscules électriques dans l'espace cosmique. Troisième communication. Kristiania, Skr. Vid. selsk. I. Mat-naturv. Klasse, 1916, No. 6 (60 avec 34 figures dans le texte). 27 cm.

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C. *Miscellaneous.*

ALDRICH, L. B. The Smithsonian eclipse expedition of June 8, 1918. Washington, D. C., Smithsonian Inst., Misc. Collect., v. 69, No. 9, 1919, 17 pp. with 4 pls.

BIRKELAND, KR. Simultaneous observations of the zodiacal light from stations of nearly equal longitude in North and South Africa. Alexandria, Cairo Sci. J., v. 9, No. 100, Jan.–Feb.–Mar., 1917 (18 with 24 figs.)

CHANT, C. A. (Editor). The Observer's handbook for 1919. Toronto, R. Astr. Soc. Can., 1919 (32). 21 cm.

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DAVIS, W. G. Obituary. Nature, London, v. 103, No. 2600, Aug. 28, 1919 (508-509).

FRANKLIN, W. S., and B. MCNUTT. A calendar of leading experiments. South Bethlehem, Pa., Franklin, MacNutt & Charles, 1918 (viii+210 with 107 figs.). 22 cm.

INTERNATIONAL RESEARCH COUNCIL. Brief note regarding the meeting at Brussels, June, 1919. Elect., London, v. 80, No. 8, Aug. 22, 1919 (188).

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MAYOR, A. G. Detecting ocean currents by observing their hydrogen-ion concentration. Philadelphia, Pa., Proc. Amer. Phil. Soc., v. 58, No. 2, 1919 (150-160).

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TERRESTRIAL MAGNETISM
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TABLE OF CONTENTS

MARCH, 1920

JUNE, 1920

SEPTEMBER, 1920

DECEMBER, 1920

Fig. 1.—Variation Observatory.

Fig. 2.—Absolute Observatory.

VIEWS OF WATHEROO MAGNETIC OBSERVATORY.

Terrestrial Magnetism
and
Atmospheric Electricity

VOLUME XXV | MARCH, 1920 | NUMBER 1

THE CONSTRUCTION AND EQUIPMENT OF THE WATHEROO MAGNETIC OBSERVATORY IN WESTERN AUSTRALIA.

BY J. A. FLEMING and W. F. WALLIS.

The general magnetic survey of the Earth nearing completion, the next step in the program of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington is the establishment of additional observatories for the study of the variations of the Earth's magnetism, and investigations in atmospheric electricity and earth currents. The paucity of magnetic observatories in the Southern Hemisphere led first to consideration of the region between Mauritius and Melbourne, Australia. Dr. Bauer, the Director of the Department, in 1911 visited Australia and conferred with those interested in geophysical investigations; as the result of these conferences Western Australia was chosen as the site of the Department's first observatory.

SITE OF THE WATHEROO OBSERVATORY.

The general region within which the proposed observatory was tentatively specified by Dr. Bauer to be was between 28° to 36° south latitude and 114° to 118° east longitude. The desiderata considered essential for the site were grouped under the different classes of work as follows: (*A*) terrestrial magnetism; (*B*) atmospheric electricity; (*C*) earth currents; (*D*) possible solar-constant observations; (*E*) general. Under (*A*) we have: (1) freedom from possible sources of artificial disturbance; (2) uniform distribution of magnetism; and (3) a fairly dry climate to eliminate objectional

humidity conditions in the variation observatory. Under (*B*) we have: (1) well removed from towns with large industrial establishments; (2) near sea level, say, not above 1,200 feet elevation; (3) the surrounding region practically flat for a radius of ½ mile with a particularly flat area within the site, say 150 yards from the buildings, for the purpose of standardizing instruments; (4) absence of trees, shrubs, etc.; and (5) not less than 50 miles from the coast in order that the observations will be representative of the land. Under (*C*) we have: (1) provision such that it will be possible to lay 2 cables for stretches of at least 10 miles at right angles to each other and preferably in the meridian and prime vertical. Under (*D*) we have: (1) dry climate with small rainfall, and (2) location at some distance from the coast. The requirements under (*E*) for seismological and certain meteorological work and for the routine office work include (1) accessibility and facilities to permit economical delivery of supplies and mail; (2) telegraph or telephone communication, (3) supply of good water for photographic work; and (4), so far as possible, conditions which will contribute to the comfort and convenience of the observers.

The southwestern part of the region specified has a heavy rainfall which is to some extent concentrated in a rainy season principally during the months of June and July; it is covered with forest, and is apparently undergoing *rapid development*. The annual rainfall at Perth averages about 33 inches and at Albany about 34 inches. The northeastern part of the area has many iron-ore deposits and is locally disturbed. A study of the conditions given in detail in the Western-Australian Yearbook, published at Perth in 1906, and in Bulletin No. 61 of the Western-Australian Geological Survey (*An outline of the physiographical geology of Western Australia*), published at Perth in 1914, indicated that probably the best locality for the observatory would be either in the northwestern part, somewhere along the lines of railway from Geraldton towards Mullewa or Northampton, or in the southeastern part in about latitude 33° south and longitude 118° east. The ore deposits and mining operations are rather extensive in the neighborhood of the first locality, and the observations made by Mr. Kidson of the Department in 1912 indicated some local disturbance. The annual rainfall is about 20 inches. The second locality was thought probably superior to the first since the rainfall is not quite as large, averaging less than 15 inches a year and, while apparently sufficiently isolated to guard against

danger from future artificial disturbances, is readily accessible both from Perth and Albany. It is also at about the eastern limit of agricultural development and relatively free of trees, thus involving small expense for clearing. There also appeared to be large areas of Government land in the neighborhood which would probably facilitate the acquirement of a sufficiently large site and offer the best chance to realize the land requirements for the proposed earth-current measurements. The distribution of magnetism over the second locality was indicated by the observations made in 1912 by Mr. Kidson to be fairly uniform, and there are no indications of extensive mineral deposits in the references consulted.

Mr. Wallis left Washington for Australia in June, 1916, to select a site; on his arrival at Perth he was joined by Mr. W. C. Parkinson of the Department, who had been engaged in magnetic-survey work in Australia. Before taking up in August, 1916, their search, Messrs. Wallis and Parkinson consulted with various government officials of the Land Office, the Survey Department, and the Geological Survey. Numerous promising locations were examined, but most of them had to be rejected because of natural local magnetic disturbances. A favorable site was found in September, 1916, at Pindar (latitude 28°.5 south, longitude 115°.8 east of Greenwich), but, since it was only about one and one-half miles from the railway, it was decided not to take the chance of future disturbance that might come with possible electrification of the railway. A second apparently favorable site was found in November, 1916, about 10 miles west of Marchagee Siding (in latitude 30°.0 south, longitude 115°.9 east of Greenwich); unfortunately, boring operations developed that only brackish water, too salty for use, could be obtained.

It was not until early in March, 1917, that a site answering all requirements as nearly as they could be fulfilled was found about 12 miles by road westward of Watheroo, 132 miles from Perth, on the Midland Railway and in latitude 30° 18′ south and longitude 115° 53′ east of Greenwich. The site is on a fine level stretch of sand-plain, clear of timber, and covered only with coarse grass and low bushes. The surrounding country is slightly undulating sand-plain, with groves of eucalyptus trees visible here and there, and distant hills rise in the east. The "soak" (pocket in sand which catches and holds rain-water) where the well is located is about one-half mile northwest of the best building site, and it was, therefore, necessary to acquire more land than had been originally

contemplated. The tract as finally selected was generously granted without cost, other than that of the survey, to the Department on behalf of the Government of Western Australia. The large area is, however, advantageous since it provides a greater safeguard against bush fires which are quite bad at times. The large size (10 chains square) of the terminal plots for the earth-current strips is also for the purpose of giving opportunity for greater protection of necessary buildings for instruments against bush fires. The total area of the site, inclusive of earth-current 10-mile strips and terminals of 10 acres each, is 240 acres.

The site is 10½ miles from the nearest point of the Midland Railway and 55 miles from the nearest point of the sea coast. The elevation above sea level is about 850 feet. The mean annual rainfall is about 15 inches. The land is too poor for agriculture and is but slightly used for grazing. There are postoffice and telephone station, railway dining-room, and general-merchandise store at Watheroo. At Moora, 24 miles south on the railway, there are several good stores, banks, hotels, and a hospital. The road to Watheroo is partly through heavy sand, and the trip of 12 miles with horse and vehicle takes about 4 hours.

The climatic conditions are generally good. The average maximum temperature during the summer in January and February is about 35°C., but the nights are generally cool with temperature falling usually below 21°C. The winter months are moderately cold; during 1918 several sharp frosts were experienced. The rainy season comes during June, July, and August. The nearest neighbors are two miles east, and there is no settlement to the west, the country being virgin sand-plain right out to the coast.

Buildings.

The observatory buildings thus far constructed under Mr. Wallis' direction in accordance with designs developed by Mr. Fleming consist of the following: (*a*) Variation observatory and office; (*b*) absolute observatory; (*c*) observers' quarters; (*d*) storehouse and workshop, and (*e*) miscellaneous small buildings including stable, laundry, etc. All are of frame construction, and (*a*) and (*b*) are strictly non-magnetic. It was, of course, necessary to purchase our own materials and to hire our own carpenters, as it was not possible to get a contractor for this kind of work.

The design of the variation observatory for constant-temperature conditions was on the basis of insulation sufficient to reduce the an-

nual temperature change inside the variation room to 5° or less, assuming a mean outside annual range of 20°C. The variation-observatory room is of sufficient size, 12 feet 6 inches by 14 feet 6 inches inside, to accommodate an eye-reading and a self-registering set of Eschenhagen variometers. For the purpose of providing better constant-temperature and ventilation conditions it was decided to incorporate the observatory office as a part of the variation observatory. A view, looking northwest, of the completed building is shown in Figure 1, Plate I.

The absolute observatory (see Figure 2, Plate I) is of sufficient size, 16 feet by 32 feet, to accommodate two sets of instruments so that simultaneous intercomparisons may be carried on under one roof without any disturbing effect of one instrument on the other. It will be noted that three stations are provided at each end of the observatory, e. g., to provide for mounting magnetometer, earth-inductor, and galvanometer. Care was taken in design and construction to make several dead-air spaces in the walls to guard against too rapid temperature changes. (Figure 2 is a view looking southwest.)

The other buildings are of usual frame construction. The dwelling has five rooms and bath with large attic. The quarters and absolute observatory, because of excessive cost of concrete, are built on jarrah posts treated with ant poison and tarred.

The water supply is from a well with windmill and tank, and three auxiliary rain-water cisterns of 2,000 gallons capacity each at the variation observatory, the absolute observatory, and the quarters, and two 1,000-gallon rain-water tanks at the storehouse and workshop. A septic tank with lateral drains is provided for sewage disposal. All piping and fittings coming near or into the observatory buildings are of non-magnetic materials.

As will be readily understood, the cost of building has been greater than anticipated, and the auxiliary buildings for atmospheric-electric, earth-current, and other work contemplated, have been deferred until building conditions are more normal and the necessary instruments, construction of which was delayed by the late war, are ready for installation. Because of the proposed use of electric motors with the atmospheric-electric instruments and the magnetic parts, it will not be feasible to consider installing the atmospheric-electric apparatus in the magnetic variation observatory, although, manifestly, several advantages would result from housing all automatic recording instruments under one roof. The

atmospheric-electric observatory will be built, therefore, as a separate unite at a considerable distance from the magnetic observatories. It will be of reinforced concrete with hollow walls and metal roof with few wall openings, thus giving good inside temperature conditions. The small houses necessary to house the instruments at the terminals of the earth-current cables will be of similar construction.

Instruments

The variation instruments consist of declination, horizontal, and vertical-intensity variometers and registering apparatus of the Eschenhagen type. The observatory was completed and the variometers installed by January 1, 1919. Except for one short interruption because of clock trouble, complete records have been obtained from that date. The required sensitivities for the intensity variometers have been secured without the use of control magnets.

The absolute instruments used to determine base-line values consist of C. I. W. magnetometer similar to the Survey of India type with modifications in design by the Department, and a Schulze earth-inductor with Plath galvanometer. Both instruments are of a sturdy, heavy construction, well suited for observatory use.[1]

In addition to the magnetic instruments, the observatory has been equipped with the following meteorological instruments: Maximum and minimum thermometers, barograph, sling psychrometer and rain gauge. At the request of the Commonwealth Meteorologist monthly weather reports are sent to the Weather Bureau Office at Perth.

Throughout the arduous work of selecting a site and construction of the buildings, Mr. Wallis has had the assistance of Mr. W. C. Parkinson, to whom the success of the undertaking is in no small measure due. The governmental and university authorities at Perth have all been most cordial and their interest and cooperation have forwarded the work greatly, and this opportunity is embraced to record the Department's appreciation of the substantial aid rendered.

[1]For procedure followed regarding magnetograph scalings, see articles by L. A. Bauer, and J. A. Fleming, in December, 1919, issue of this Journal, pp. 149–155.

CORRECTIONS FOR NON-CYCLIC CHANGE.

By Charles Chree.

When we are getting out the diurnal inequality of a magnetic element, whether from all days of the month or from selected days, a difference usually presents itself between the values at the first and second midnights of the mean day. The excess of the value at the second midnight over that at the first midnight is what is known as the non-cyclic change. To obtain a really periodic diurnal variation, a correction has to be applied, which makes the two midnight values equal. In the absence of special knowledge of the cause or causes of the n. c. change, the only practical way of calculating a correction is to assume that the n. c. change comes in at a uniform rate throughout the 24 hours. This is practically what would happen if it arose from the secular change, or from any periodic change of long period such as a year. Supposing $+N$ to be the n. c. change, the corrections are obviously as follows:—

$+(N/2)$ at 0h, $+(11/12)N/2$ at 1h, $+(10/12)N/2$ at 2h... $+(1/12)N/2$ at 11h;

$-(N/2)$ at 24h, $-(11/12)N/2$ at 23h, $-(10/12)N/2$ at 22h... $-(1/12)N/2$ at 13h.

The central hour of the day, 12h, has no correction. The calculation of a table of n. c. corrections, to the ordinary degree of accuracy, is simple, especially if one uses Crelle's or similar tables. It is unnecessary to work out the decimals for values of N greater than 24, owing to the following simple relation: Let N be any real number, integral or otherwise, and let $N^1=N+24$. At hour $n-r$ (or $n+r$) of the day the arithmetical values of the correction for n. c. changes N and N^1 are respectively $(r/24)N$ and $(r/24)N^1$. The excess of the latter correction over the former is $(r/24)$ (N^1-N), i. e. is simply r. If then the n. c. hourly corrections have been calculated for a change N, all that remains to be done to obtain them for a change N^1 is to add to the corrections obtained for N: 1 at 11h, 2 at 10h... 11 at 11h, and 12 at midnight. This the ordinary calculator can do in his head. Thus a table including values of N from 1 to 24 would really suffice. The accompanying table, however, is extended to $N=50$. In all cases where the second decimal figure was 5 the figure has been thrown down, on the principle that no larger correction should be applied at any hour than is absolutely necessary. If the n. c. change is positive, i. e., if the second midnight value is the larger, the correction has the positive sign for hours 0 to 11, the negative sign for hours 13 to 24. The reverse of course is true if the second midnight value is the smaller. The sums of the morning and afternoon corrections are necessarily equal but opposite in sign in all cases, so that the mean value for the day is unaffected. If corrections to the nearest unit suffice, the table can be simplified accordingly. If corrections are desired to two places of decimals, the decimal in the table may be moved one place forward. The table then applies only to n. c. changes varying from 0.1 to 5.0 and it may be found convenient to extend it by means of the relation indicated above.

Correction for non-cyclic change at hours stated.

Non-cyclic change	Midt.	1&23	2&22	3&21	4&20	5&19	6&18	7&17	8&16	9&15	10&14	11&13
1	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.0
2	1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.4	0.3	0.2	0.2	0.1
3	1.5	1.4	1.2	1.1	1.0	0.9	0.7	0.6	0.5	0.4	0.2	0.1
4	2.0	1.8	1.7	1.5	1.3	1.2	1.0	0.8	0.7	0.5	0.3	0.2
5	2.5	2.3	2.1	1.9	1.7	1.5	1.2	1.0	0.8	0.6	0.4	0.2
6	3.0	2.7	2.5	2.2	2.0	1.7	1.5	1.2	1.0	0.7	0.5	0.2
7	3.5	3.2	2.9	2.6	2.3	2.0	1.7	1.5	1.2	0.9	0.6	0.3
8	4.0	3.7	3.3	3.0	2.7	2.3	2.0	1.7	1.3	1.0	0.7	0.3
9	4.5	4.1	3.7	3.4	3.0	2.6	2.2	1.9	1.5	1.1	0.7	0.4
10	5.0	4.6	4.2	3.7	3.3	2.9	2.5	2.1	1.7	1.2	0.8	0.4
11	5.5	5.0	4.6	4.1	3.7	3.2	2.7	2.3	1.8	1.4	0.9	0.5
12	6.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5	1.0	0.5
13	6.5	6.0	5.4	4.9	4.3	3.8	3.2	2.7	2.2	1.6	1.1	0.5
14	7.0	6.4	5.8	5.2	4.7	4.1	3.5	2.9	2.3	1.7	1.2	0.6
15	7.5	6.9	6.2	5.6	5.0	4.4	3.7	3.1	2.5	1.9	1.2	0.6
16	8.0	7.3	6.7	6.0	5.3	4.7	4.0	3.3	2.7	2.0	1.3	0.7
17	8.5	7.8	7.1	6.4	5.7	5.0	4.2	3.5	2.8	2.1	1.4	0.7
18	9.0	8.2	7.5	6.7	6.0	5.2	4.5	3.7	3.0	2.2	1.5	0.7
19	9.5	8.7	7.9	7.1	6.3	5.5	4.7	4.0	3.2	2.4	1.6	0.8
20	10.0	9.2	8.3	7.5	6.7	5.8	5.0	4.2	3.3	2.5	1.7	0.8
21	10.5	9.6	8.7	7.9	7.0	6.1	5.2	4.4	3.5	2.6	1.7	0.9
22	11.0	10.1	9.2	8.2	7.3	6.4	5.5	4.6	3.7	2.7	1.8	0.9
23	11.5	10.5	9.6	8.6	7.7	6.7	5.7	4.8	3.8	2.9	1.9	1.0
24	12.0	11.0	10.0	9.0	8.0	7.0	6.0	5.0	4.0	3.0	2.0	1.0
25	12.5	11.5	10.4	9.4	8.3	7.3	6.2	5.2	4.2	3.1	2.1	1.0
26	13.0	11.9	10.8	9.7	8.7	7.6	6.5	5.4	4.3	3.2	2.2	1.1
27	13.5	12.4	11.2	10.1	9.0	7.9	6.7	5.6	4.5	3.4	2.2	1.1
28	14.0	12.8	11.7	10.5	9.3	8.2	7.0	5.8	4.7	3.5	2.3	1.2
29	14.5	13.3	12.1	10.9	9.7	8.5	7.2	6.0	4.8	3.6	2.4	1.2
30	15.0	13.7	12.5	11.2	10.0	8.7	7.5	6.2	5.0	3.7	2.5	1.2
31	15.5	14.2	12.9	11.6	10.3	9.0	7.7	6.5	5.2	3.9	2.6	1.3
32	16.0	14.7	13.3	12.0	10.7	9.3	8.0	6.7	5.3	4.0	2.7	1.3
33	16.5	15.1	13.7	12.4	11.0	9.6	8.2	6.9	5.5	4.1	2.7	1.4
34	17.0	15.6	14.2	12.7	11.3	9.9	8.5	7.1	5.7	4.2	2.8	1.4
35	17.5	16.0	14.6	13.1	11.7	10.2	8.7	7.3	5.8	4.4	2.9	1.5
36	18.0	16.5	15.0	13.5	12.0	10.5	9.0	7.5	6.0	4.5	3.0	1.5
37	18.5	16.9	15.4	13.9	12.3	10.8	9.2	7.7	6.2	4.6	3.1	1.5
38	19.0	17.4	15.8	14.2	12.7	11.1	9.5	7.9	6.3	4.7	3.2	1.6
39	19.5	17.9	16.2	14.6	13.0	11.4	9.7	8.1	6.5	4.9	3.2	1.6
40	20.0	18.3	16.7	15.0	13.3	11.7	10.0	8.3	6.7	5.0	3.3	1.7
41	20.5	18.8	17.1	15.4	13.7	12.0	10.2	8.5	6.8	5.1	3.4	1.7
42	21.0	19.2	17.5	15.7	14.0	12.2	10.5	8.7	7.0	5.2	3.5	1.7
43	21.5	19.7	17.9	16.1	14.3	12.5	10.7	9.0	7.2	5.4	3.6	1.8
44	22.0	20.2	18.3	16.5	14.7	12.8	11.0	9.2	7.3	5.5	3.7	1.8
45	22.5	20.6	18.7	16.9	15.0	13.1	11.2	9.4	7.5	5.6	3.7	1.9
46	23.0	21.1	19.2	17.2	15.3	13.4	11.5	9.6	7.7	5.7	3.8	1.9
47	23.5	21.5	19.6	17.6	15.7	13.7	11.7	9.8	7.8	5.9	3.9	2.0
48	24.0	22.0	20.0	18.0	16.0	14.0	12.0	10.0	8.0	6.0	4.0	2.0
49	24.5	22.5	20.4	18.4	16.3	14.3	12.2	10.2	8.2	6.1	4.1	2.0
50	25.0	22.9	20.8	18.7	16.7	14.6	12.5	10.4	8.3	6.2	4.2	2.1

PRELIMINARY RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE FROM WASHINGTON, D. C., TO DAKAR, AFRICA, THENCE TO BUENOS AIRES, SOUTH AMERICA, OCTOBER, 1919, TO JANUARY, 1920.[1]

By J. P. Ault, *Commanding the Carnegie.*

(*Observers:* J. P. Ault, H. F. Johnston, R. R. Mills, H. R. Grummann, and R. Pemberton.)

Date	Latitude	Long. East of Gr.	Carnegie Values			Chart Differences[2]					
			Decl'n	Incl'n	Hor. Int.	Decl'n and Incl'n			Hor. Int.[3]		
						Brit.	Ger.	U.S.	Brit.	Ger.	U.S.
1919	° ′	° ′	°	°	c.g.s.	°	°	°			
Oct. 14	38 04 N	283 45	6.4W	......	.....	0.3W	0.0	0.9W	.....	.....	.....
15	37 12 N	283 52	6.1W	......	.....	0.4W	0.4W	0.7W	.....	.....	.....
19	36 45 N	284 23	6.2W	......	.....	0.3W	0.3W	0.5W	.....	.....	.....
20	36 03 N	285 40	6.5W	......	.....	0.2W	0.1W	0.0	.....	.....	.....
20	35 40 N	286 20	......	68.3N	.209	1.3N	1.1N	0.3N	−15	−17	+1
21	36 32 N	286 44	8.1W	......	.....	0.7W	0.7W	0.4W	.....	.....	.....
21	37 01 N	287 34	......	69.7N	.199	1.4N	1.0N	0.4N	−11	−15	0
22	38 03 N	290 39	12.1W	......	.....	0.5W	0.4W	0.1W	.....	.....	.....
22	38 30 N	291 58	......	70.5N	.189	0.8N	0.6N	0.3N	−8	−9	−2
23	38 38 N	295 20	16.1W	......	.....	0.6W	1.1W	0.5W	.....	.....	.....
23	38 24 N	295 54	......	69.9N	.192	0.8N	0.4N	0.0	−4	−3	+1
23	38 21 N	296 00	16.1W	......	.....	0.2W	0.9W	0.5W	.....	.....	.....
24	38 04 N	297 35	......	69.6N	.195	1.0N	0.5N	0.3N	−1	−2	+1
25	37 05 N	297 58	16.5W	......	.....	0.5W	1.2W	0.6W	.....	.....	.....
25	36 52 N	298 01	......	68.7N	.199	1.5N	0.5N	0.4N	−4	−6	0
26	38 25 N	298 54	17.2W	......	.....	0.6E	0.2W	0.2E	.....	.....	.....
26	39 01 N	299 06	18.5W	......	.....	0.0	1.1W	0.3W	.....	.....	.....
27	39 20 N	301 49	20.3W	......	.....	0.1W	1.3W	0.6W	.....	.....	.....
27	39 18 N	303 11	......	69.5N	.190	0.9N	0.0	0.2N	0	+1	+1
28	39 04 N	305 56	22.1W	......	.....	0.1W	1.3W	0.2W	.....	.....	.....
28	38 39 N	306 49	......	68.0N	.197	0.6N	0.6S	0.1N	+3	+7	+1
28	38 27 N	307 01	22.2W	......	.....	0.3W	1.6W	0.6W	.....	.....	.....
29	38 24 N	308 18	22.5W	......	.....	0.2W	1.5W	0.2W	.....	.....	.....
29	38 30 N	309 55	......	67.4N	.199	0.5N	0.8S	0.4N	+5	+7	0
29	38 35 N	310 24	23.0W	......	.....	0.0	1.0W	0.1W	.....	.....	.....
30	38 50 N	313 43	23.7W	......	.....	0.2E	0.8W	0.0	.....	.....	.....
30	38 54 N	314 41	......	66.3N	.205	0.2N	1.1S	0.2N	+11	+14	+3
Nov. 1	38 29 N	316 17	24.0W	......	.....	0.1E	1.0W	0.2W	.....	.....	.....
1	38 25 N	316 39	......	65.6N	.207	0.2N	1.4S	0.6N	+11	+12	0
1	38 25 N	316 54	24.6W	......	.....	0.5W	1.6W	0.9W	.....	.....	.....

[1]For previous table, see *Terr. Mag.*, v. 23, pp. 139, 140.

[2]Charts used for comparison: U. S. Hydrographic Office Charts Nos. 1700, 1701, and 2406 for 1920; British Admiralty Charts No. 3775 for 1917, 3598 and 3603 for 1907; Reichs-Marine-Amt Charts Tit. XIV, No. 2 for 1910; Tit. XIV, Nos. 2a and 2b for 1905. The chart differences are obtained by subtracting chart values, derived as explained in previous sentence, from the observed *Carnegie* values. The letter E signifies that the chart value for east declination is smaller, or the chart value for west declination larger, than the *Carnegie* value; W signifies the reverse. The letter N signifies that the derived chart value for northerly inclination is smaller, or for southerly inclination larger, than the *Carnegie* value; S signifies the reverse. The plus sign signifies that the derived chart value for horizontal intensity is smaller than the *Carnegie* value, the minus sign meaning, of course, the reverse. Secular corrections have been applied to declinations only.

[3]Expressed in units of third decimal C. G. S.

Date	Latitude	Long. East of Gr.	Carnegie Values			Chart Differences[2]					
			Decl'n	Incl'n	Hor. Int.	Decl'n and Incl'n			Hor. Int.[3]		
						Brit.	Ger.	U.S.	Brit.	Ger.	U. S.
1919	° ′	° ′	°	°	c.g.s.	°	°	°			
Nov. 2	38 26 N	319 00	23.9W	......	.....	0.2E	0.5W	0.1W	.....	.....	.....
2	38 28 N	319 46	......	64.6N	.210	0.3S	1.7S	0.5N	+13	+14	+1
2	38 27 N	320 02	24.2W	......	.....	0.1W	0.8W	0.4W	.....	.....	.....
3	38 39 N	321 57	......	64.0N	.212	0.4S	2.0S	0.3N	+14	+15	+2
4	39 15 N	322 30	24.4W	......	.....	0.2W	0.6W	0.4W	.....	.....	.....
4	39 05 N	323 34	......	63.9N	.211	0.5S	2.1S	0.3N	+14	+14	+1
4	39 06 N	323 58	24.2W	......	.....	0.3W	0.4W	0.5W	.....	.....	.....
5	38 57 N	326 47	23.7W	......	.....	0.5W	0.2W	0.5W	.....	.....	.....
5	38 53 N	327 47	......	63.0N	.215	0.1S	1.9S	0.8N	+14	+14	0
5	38 53 N	328 07	23.1W	......	.....	0.2W	0.3E	0.2W	.....	.....	.....
6	38 48 N	329 18	22.7W	......	.....	0.1W	0.4E	0.1W	.....	.....	.....
6	38 45 N	329 33	......	62.0N	.219	0.7S	2.2S	0.3N	+15	+15	+3
7	37 30 N	329 46	22.3W	......	.....	0.2W	0.1E	0.1W	.....	.....	.....
7	37 02 N	329 51	......	60.8N	.225	0.6S	2.1S	0.2N	+12	+13	+3
7	36 52 N	329 52	21.9W	......	.....	0.1W	0.3E	0.1E	.....	.....	.....
8	35 52 N	329 58	21.6W	......	.....	0.1W	0.1E	0.1E	.....	.....	.....
8	35 37 N	329 44	......	59.6N	.230	0.7S	2.2S	0.0	+10	+12	+3
9	35 39 N	331 37	21.0W	......	.....	0.1E	0.3E	0.3E	.....	.....	.....
9	35 35 N	332 08	......	58.9N	.232	0.8S	2.3S	0.1S	+8	+12	+3
10	35 14 N	333 59	20.8W	......	.....	0.3W	0.1W	0.2W	.....	.....	.....
10	35 08 N	334 17	......	57.9N	.235	0.9S	2.4S	0.3S	+7	+11	+2
10	35 05 N	334 29	20.4W	......	.....	0.1W	0.2E	0.0	.....	.....	.....
11	34 21 N	335 34	20.1W	......	.....	0.2W	0.1W	0.1W	.....	.....	.....
11	34 09 N	335 58	......	56.4N	.240	0.7S	2.6S	0.5S	+6	+11	+3
11	34 02 N	336 11	19.8W	......	.....	0.1W	0.0	0.1W	.....	.....	.....
12	32 48 N	338 16	......	54.5N	.248	0.5S	2.4S	0.5S	+3	+10	+2
13	30 39 N	340 07	18.0W	......	.....	0.3E	0.0	0.3E	.....	.....	.....
13	30 02 N	340 18	......	50.4N	.262	1.0S	3.3S	0.6S	+2	+13	+2
13	29 43 N	340 23	18.0W	......	.....	0.1E	0.2W	0.1E	.....	.....	.....
14	27 54 N	340 42	17.8W	......	.....	0.1E	0.3W	0.2E	.....	.....	.....
14	27 08 N	340 47	......	46.3N	.275	2.0S	4.9S	0.7S	+5	+18	+3
14	26 58 N	340 49	17.9W	......	.....	0.1W	0.6W	0.1E	.....	.....	.....
15	25 50 N	340 39	17.6W	......	.....	0.2E	0.3W	0.4E	.....	.....	.....
15	25 30 N	340 32	......	44.6N	.278	2.5S	5.3S	0.4S	+3	+17	+1
15	25 25 N	340 30	17.6W	......	.....	0.2E	0.4W	0.5E	.....	.....	.....
16	25 03 N	340 04	18.1W	......	.....	0.1W	0.8W	0.1E	.....	.....	.....
17	25 03 N	340 32	17.7W	......	.....	0.1E	0.5W	0.4E	.....	.....	.....
17	24 35 N	340 26	......	43.4N	.282	2.5S	5.3S	0.6S	+4	+19	+2
18	22 32 N	340 19	18.1W	......	.....	0.3W	0.7W	0.1E	.....	.....	.....
18	21 44 N	340 28	......	39.0N	.291	3.4S	6.0S	1.0S	+4	+18	0
18	21 30 N	340 32	18.1W	......	.....	0.3W	0.6W	0.0	.....	.....	.....
19	19 39 N	340 01	18.7W	......	.....	0.7W	1.1W	0.3W	.....	.....	.....
19	18 56 N	341 09	......	34.2N	.298	3.3S	6.3S	1.1S	+5	+16	+1
19	18 42 N	341 13	18.3W	......	.....	0.5W	0.8W	0.1W	.....	.....	.....
20	16 59 N	341 49	18.2W	......	.....	0.4W	0.6W	0.0	.....	.....	.....
20	16 23 N	341 55	......	29.6N	.304	2.9S	6.4S	1.2S	+5	+16	+2
20	16 11 N	342 00	18.2W	......	.....	0.3W	0.4W	0.0	.....	.....	.....
21	15 12 N	342 25	18.4W	......	.....	0.4W	0.6W	0.2W	.....	.....	.....
21	14 59 N	342 29	......	26.3N	.308	3.5S	7.5S	1.2S	+7	+18	+4
22	14 53 N	342 28	18.4W	......	.....	0.4W	0.6W	0.2W	.....	.....	.....

Date	Latitude	Long. East of Gr.	Carnegie Values			Chart Differences[2]					
						Decl'n and Incl'n			Hor. Int.[3]		
			Decl'n	Incl'n	Hor. Int.	Brit.	Ger.	U. S.	Brit.	Ger.	U. S.
1919	° ′	° ′	°	°	c.g.s.	°	°	°			
Nov. 27	13 06 N	342 25	18.6W	......	.....	0.3W	0.4W	0.2W	.....	.....	.....
27	12 27 N	342 24	......	21.9N	.311	2.7S	7.3S	1.4S	+9	+15	+4
27	12 13 N	342 25	18.7W	......	.....	0.2W	0.3W	0.1W	.....	.....	.....
28	11 01 N	342 38	18.9W	......	.....	0.2W	0.2W	0.2W	.....	.....	.....
28	10 15 N	343 19	......	17.2N	.309	1.4S	7.8S	0.8S	+4	+9	+1
28	10 08 N	343 25	19.2W	......	.....	0.5W	0.5W	0.5W	.....	.....	.....
29	9 37 N	343 46	19.0W	......	.....	0.2W	0.2W	0.3W	.....	.....	.....
29	9 24 N	343 55	......	14.9N	.310	2.0S	8.1S	0.9S	+5	+9	+2
30	8 50 N	344 33	19.0W	......	.....	0.1W	0.2W	0.3W	.....	.....	.....
Dec. 1	7 54 N	345 40	18.8W	......	.....	0.2E	0.0	0.1W	.....	.....	.....
1	7 39 N	345 55	......	9.7N	.312	1.8S	8.0S	0.3S	+8	+10	+4
1	7 38 N	346 02	19.0W	......	.....	0.0	0.2W	0.4W	.....	.....	.....
2	7 20 N	346 35	18.6W	......	.....	0.3E	0.1E	0.0	.....	.....	.....
3	6 46 N	346 33	18.7W	......	.....	0.4E	0.1E	0.0	.....	.....	.....
4	6 30 N	346 37	18.8W	......	.....	0.4 E	0.1E	0.1W	.....	.....	.....
4	6 18 N	347 00	......	5.6N	.309	1.7S	8.6S	1.4S	+6	+8	+2
5	5 53 N	348 12	......	3.7N	.307	1.2S	8.0S	1.5S	+3	+7	0
5	5 48 N	348 20	18.4W	......	.....	0.5E	0.2E	0.2E	.....	.....	.....
6	5 11 N	349 13	......	1.3N	.305	2.0S	8.7S	1.3S	+1	+5	−2
6	5 08 N	349 17	18.5W	......	.....	0.4E	0.0	0.0	.....	.....	.....
7	4 51 N	350 13	18.2W	......	.....	0.6E	0.2E	0.3E	.....	.....	.....
7	4 48 N	350 40	......	0.9S	.304	1.6S	8.4S	1.2S	0	+4	−2
7	4 45 N	350 50	18.1W	......	.....	0.5E	0.2E	0.4E	.....	.....	.....
8	4 22 N	351 33	18.0W	......	.....	0.5E	0.3E	0.3E	.....	.....	.....
8	4 20 N	352 04	......	2.8S	.305	1.8S	7.8S	1.0S	0	+5	−1
*8	4 17 N	352 17	17.3W	......	.....	1.1E	0.7E	0.9E	.....	.....	.....
9	3 38 N	351 58	17.8W	......	.....	0.9E	0.6E	0.7E	.....	.....	.....
9	3 41 N	352 28	......	4.3S	.303	2.3S	7.5S	0.7S	−1	+5	−1
9	3 44 N	352 42	17.5W	......	.....	1.0E	0.4E	0.8E	.....	.....	.....
Dec. 10	4 01 N	353 46	17.0W	......	.....	1.0E	0.4E	1.0E	.....	.....	.....
10	4 07 N	354 29	......	4.8S	.304	1.9S	7.0S	0.8S	−2	+4	−2
10	4 08 N	354 40	16.7W	......	.....	1.0E	0.4E	0.9E	.....	.....	.....
11	4 05 N	355 28	16.4W	......	.....	1.0E	0.4E	1.0E	.....	.....	.....
12	4 10 N	356 08	16.1W	......	.....	1.0E	0.3E	1.0E	.....	.....	.....
12	3 57 N	356 22	......	6.3S	.303	1.5S	5.3S	0.8S	−3	+3	−3
12	3 51 N	356 33	16.0W	......	.....	1.1E	0.5E	1.1E	.....	.....	.....
13	3 37 N	357 36	15.7W	......	.....	1.1E	0.7E	1.1E	.....	.....	.....
13	3 31 N	358 15	......	8.8S	.303	2.2S	5.8S	1.8S	−4	+3	−3
13	3 25 N	358 26	15.4W	......	.....	1.1E	0.6E	1.1E	.....	.....	.....
14	2 51 N	359 29	......	10.8S	.300	2.1S	5.8S	2.0S	−6	+3	−4
14	2 46 N	359 34	15.2W	......	.....	1.0E	0.7E	1.0E	.....	.....	.....
15	2 14 N	0 05	15 2W	......	.....	1.0E	0.6E	1.1E	.....	.....	.....
15	1 48 N	0 29	......	13.7S	.297	2.7S	5.7S	2.7S	−7	+2	−3
15	1 38 N	0 36	15.1W	......	.....	1.2E	0.9E	1.2E	.....	.....	.....
16	1 11 N	1 21	15.1W	......	.....	1.0E	0.7E	1.0E	.....	.....	.....
16	0 52 N	1 53	......	16.2S	.293	2.8S	5.7S	2.7S	−10	0	−2
16	0 44 N	2 07	15.0W	......	.....	1.0E	0.6E	1.0E	.....	.....	.....
17	0 12 N	3 22	14.6W	......	.....	1.1E	0.9E	1.0E	.....	.....	.....
17	0 06 S	3 58	......	19.2S	.292	2.4S	5.0S	3.2S	−9	+2	+1
17	0 18 S	4 10	14.3W	......	.....	1.3E	1.0E	1.2E	.....	.....	.....

*Local disturbance near Cape Palmas.

Date	Latitude	Long. East of Gr.	Carnegie Values			Chart Differences[2]					
			Decl'n	Incl'n	Hor. Int.	Decl'n and Incl'n			Hor. Int.[3]		
						Brit.	Ger.	U. S.	Brit.	Ger.	U. S.
1919	° ′	° ′	°	°	c.g.s.	°	°	°			
Dec. 18	1 23 S	4 50	......	22.1S	.286	3.0S	5.0S	3.3S	−11	0	+1
19	0 57 S	3 44	15.0W	......	.....	1.1E	0.7E	1.2E	.....	.....	.....
19	0 37 S	3 25	......	19.6S	.289	2.6S	5.0S	2.6S	−11	+1	0
20	0 23 S	3 23	14.7W	......	.....	1.3E	1.0E	1.3E	.....	.....	.....
20	0 18 S	3 00	......	19.1S	.289	2.6S	5.1S	2.9S	−11	0	−1
20	0 17 S	2 53	14.8W	......	.....	1.4E	1.1E	1.4E			
21	0 26 S	1 54	15.5W	......	.....	1.3E	0.8E	1.3E	.....	.....	.....
21	0 34 S	1 20	......	19.0S	.289	3.1S	6.2S	3.0S	−11	+2	+1
21	0 38 S	1 08	15.7W	......	.....	1.4E	0.8E	1.3E	.....	.....	.....
22	1 07 S	0 16	16.4W	......	.....	1.4E	0.5E	1.1E	.....	.....	.....
22	1 19 S	359 55	......	19.5S	.285	3.4S	7.8S	3.2S	−11	0	0
22	1 26 S	359 41	16.7W	......	.....	1.4E	0.6E	1.1E	.....	.....	.....
23	1 45 S	358 23	17.4W	......	.....	1.3E	0.6E	0.8E	.....	.....	.....
23	2 05 S	357 47	......	19.6S	.281	3.3S	8.2S	2.6S	−12	+1	+1
23	2 16 S	357 29	17.8W	......	.....	1.4E	0.6E	0.8E	.....	.....	.....
24	3 01 S	356 16	18.7W	......	.....	1.2E	0.3E	0.4E	.....	.....	.....
24	3 29 S	355 36	......	20.8S	.276	3.6S	9.6S	3.1S	−12	−1	0
24	3 38 S	355 21	19.4W	......	.....	0.9E	0.0	0.2E	.....	.....	.....
25	4 32 S	354 01	20.2W	......	.....	0.5E	0.1E	0.1W	.....	.....	.....
25	5 00 S	353 16	......	21.5S	.270	4.1S	10.3S	1.9S	−12	−4	0
25	5 13 S	352 53	20.7W	......	.....	0.4E	0.3E	0.1W	.....	.....	.....
26	6 35 S	351 27	21.3W	......	.....	0.5E	0.4E	0.1W	.....	.....	.....
26	7 06 S	350 55	......	23.3S	.262	4.4S	10.8S	1.6S	−11	−8	+1
27	8 38 S	349 20	22.9W	......	.....	0.4W	0.1W	0.6W	.....	.....	.....
27	9 18 S	348 42	......	24.3S	.256	4.4S	10.5S	0.9S	−11	−6	+1
27	9 51 S	348 10	23.3W	......	.....	0.5W	0.1W	0.5W	.....	.....	.....
28	10 47 S	347 01	23.4W	......	.....	0.3W	0.1E	0.2W	.....	.....	.....
28	11 18 S	346 25	......	25.2S	.250	4.2S	10.4S	0.7S	−11	−7	0
28	11 31 S	346 12	23.9W	......	.....	0.7W	0.3W	0.4W	.....	.....	.....
29	12 35 S	345 02	23.8W	......	.....	0.3W	0.0	0.0	.....	.....	.....
29	13 16 S	344 15	......	25.8S	.245	3.8S	10.4S	0.8S	−10	−5	0
29	13 32 S	343 59	24.1W	......	.....	0.5W	0.3W	0.2W	.....	.....	.....
30	14 38 S	342 51	24.0W	......	.....	0.4W	0.2W	0.1W	.....	.....	.....
30	15 31 S	342 00	......	26.4S	.240	3.9S	9.5S	0.6S	−10	−2	0
30	15 44 S	341 47	24.0W	......	.....	0.6W	0.2W	0.3W	.....	.....	.....
31	16 50 S	340 42	23.7W	......	.....	0.5W	0.1W	0.2W	.....	.....	.....
31	17 38 S	339 55	......	27.1S	.237	3.9S	9.5S	0.8S	−6	−1	+1
31	17 54 S	339 39	23.7W	......	.....	0.7W	0.4W	0.4W	.....	.....	.....
1920											
Jan. 1	18 47 S	338 48	23.3W	......	.....	0.6W	0.2W	0.2W	.....	.....	.....
1	19 20 S	338 17	......	27.8S	.233	3.7S	9.0S	0.8S	−6	−1	0
1	19 30 S	338 06	23.2W	......	.....	0.6W	0.2W	0.4W	.....	.....	.....
2	20 12 S	337 23	23.0W	......	.....	0.7W	0.5W	0.5W	.....	.....	.....
2	20 48 S	336 46	......	28.3S	.230	4.1S	8.6S	1.2S	−6	−1	−1
2	20 57 S	336 38	22.3W	......	.....	0.3W	0.0	0.1W	.....	.....	.....
3	21 41 S	335 54	22.6W	......	.....	0.8W	0.6W	0.8W	.....	.....	.....
3	22 24 S	335 09	......	29.1S	.227	4.3S	8.5S	1.6S	−5	−3	−1
3	22 38 S	334 52	22.1W	......	.....	0.8W	0.6W	0.7W	.....	.....	.....
4	23 25 S	334 03	21.7W	......	.....	0.8W	0.4W	0.7W	.....	.....	.....
4	23 55 S	333 35	......	29.3S	.226	4.0S	8.5S	1.7S	−5	−4	0

Date	Latitude	Long. East of Gr.	Carnegie Values			Chart Differences[2]					
			Decl'n	Incl'n	Hor. Int.	Decl'n and Incl'n			Hor. Int.[3]		
						Brit.	Ger.	U. S.	Brit.	Ger.	U. S.
1920	° ′	° ′	°	°	c.g.s.	°	°	°			
Jan. 4	24 02 S	333 31	21.5W	......	.....	0.9W	0.8W	0.7W	.....	.....	.....
5	24 32 S	333 06	20.9W	......	.....	0.6W	0.5W	0.3W	.....	.....	.....
5	24 59 S	332 38	......	29.8S	.223	4.1S	7.9S	1.8S	−7	−6	−2
5	25 10 S	332 23	20.8W	......	.....	0.8W	0.6W	0.5W	.....	.....	.....
6	26 02 S	331 14	20.0W	......	.....	0.7W	0.5W	0.5W	.....	.....	.....
6	26 43 S	330 23	......	30.2S	.223	4.2S	7.4S	2.2S	−6	−7	−1
6	26 55 S	330 11	19.3W	......	.....	0.6W	0.5W	0.6W	.....	.....	.....
7	27 54 S	329 29	19.2W	......	.....	1.0W	1.0W	1.1W	.....	.....	.....
7	28 07 S	329 12	......	30.1S	.220	3.3S	6.3S	1.6S	−8	−10	−3
8	28 58 S	326 11	......	29.6S	.222	3.6S	5.9S	2.2S	−7	−9	−3
9	30 12 S	322 50	......	28.9S	.224	3.5S	5.2S	2.2S	−6	−10	−2
9	30 19 S	322 31	13.6W	......	.....	0.3W	0.3W	0.1W	.....	.....	.....
9	30 22 S	322 25	14.1W	......	.....	0.9W	0.8W	0.8W	.....	.....	.....
10	30 51 S	321 53	13.4W	......	.....	0.7W	0.6W	0.6W	.....	.....	.....
10	31 06 S	321 25	......	28.9S	.224	2.8S	4.9S	2.0S	−7	−11	−2
10	31 16 S	321 06	12.6W	......	.....	0.3W	0.3W	0.6W	.....	.....	.....
11	32 02 S	319 51	11.3W	......	.....	0.2W	0.2W	0.3W	.....	.....	.....
11	32 49 S	319 18	......	29.5S	.227	2.2S	4.1S	1.9S	−6	−10	0
11	33 04 S	319 13	10.4W	......	.....	0.0	0.1W	0.2W	.....	.....	.....
12	32 58 S	317 58	9.8W	......	.....	0.2W	0.6W	0.5W	.....	.....	.....
13	33 31 S	316 26	8.3W	......	.....	0.1W	0.3W	0.2W	.....	.....	.....
13	33 57 S	315 59	......	29.6S	.230	1.6S	3.5S	1.9S	−7	−9	+1
13	34 01 S	315 58	7.8W	......	.....	0.1W	0.5W	0.1W	.....	.....	.....
13	33 59 S	315 56	7.8W	......	.....	0.1W	0.5W	0.1W	.....	.....	.....
14	33 58 S	315 37	7.7W	......	.....	0.2W	0.6W	0.3W	.....	.....	.....
14	34 00 S	314 45	......	29.3S	.230	1.5S	3.4S	1.8S	−8	−10	0
14	33 54 S	314 14	6.6W	......	.....	0.1W	0.2W	0.4W	.....	.....	.....
15	33 40 S	312 27	5.1W	......	.....	0.1E	0.2W	0.2W	.....	.....	.....
15	33 34 S	311 44	......	28.0S	.234	1.1S	2.9S	1.3S	−7	−9	0
15	33 34 S	311 28	4.4W	......	.....	0.0	0.2W	0.3W	.....	.....	.....
16	33 40 S	310 42	3.4W	......	.....	0.2E	0.1E	0.1E	.....	.....	.....
16	34 14 S	309 14	......	28.2S	.236	0.6S	1.8S	1.2S	−8	−9	−1
16	34 20 S	308 36	1.6W	......	.....	0.2E	0.2E	0.1W	.....	.....	.....
16	34 21 S	308 24	1.3W	......	.....	0.2E	0.3E	0.1E	.....	.....	.....
17	34 29 S	306 37	0.1E	......	.....	0.2E	0.2E	0.1W	.....	.....	.....
18	35 01 S	304 45	2.0E	......	.....	0.1E	0.1E	0.0	.....	.....	.....

LETTERS TO EDITOR

MAGNETIC STORM OF AUGUST 11–12, 1919, AS RECORDED AT THE HONOLULU MAGNETIC OBSERVATORY.

Below are given the data for the magnetic storm of August 11–12, 1919, derived from the records of the Honolulu Observatory, similar to those for the other observatories of the United States Coast and Geodetic Survey, published in the December, 1919, issue (pp. 171–173). Greenwich mean civil time is used in the Table.

Times of salient points and corresponding values.

Declination			Hor. Intensity			Vert. Intensity		
Phase	Time	Value	Phase	Time	Value	Phase	Time	Value
	h m	° ′		h m	γ		h m	γ
Normal....	.. ..	+9 51.0	Normal...	.. ..	28860	Normal...	.. ..	23750
Beginning..	6 57	52.9	Beginning.	6 57	28860	Beginning.	6 57	746
Reversal ...	6 58	53.1	Maximum.	7 20	29007	Reversal ..	6 59	803
Reversal ...	6 59	52.3	Minimum .	7 54	28921	Minimum.	7 53	729
Maximum..	7 50	60.6	Maximum.	7 57	29079	Maximum.	7 56	828
Minimum ..	8 37	48.9	Minimum .	9 57	28488	Minimum .	8 32	696
Maximum..	9 22	55.6	Maximum.	24 10	28912	Maximum.	24 53	810
Minimum ..	15 49	43.4				Minimum .	25 34	648
Maximum..	16 58	64.8						

R. L. FARIS,
Assistant Superintendent.

MAGNETIC STORM OF DECEMBER 15, 1919, AS RECORDED AT THE WATHEROO MAGNETIC OBSERVATORY.

The first signs of a disturbance showed at $5^h\ 45^m$ G. M. T. on December 14, when a gradual decrease in H commenced. In the next $2\frac{1}{4}$ hours the fall totalled about 60γ. From $13^h\ 15^m$ on the 14th. there were slight disturbances in all elements until $8^h\ 50^m$ on the 15th., when the disturbances began to increase in violence.

The maximum violence was between $11^h.0$ and $12^h.5$. After that there was a gradual steadying down until at $21^h.0$ on December 15 all was again almost quiet.

The *H*-record just went off the bottom of the paper on one occasion. The following data apply to December 15.

	Maximum		Minimum		Approx.	
	h	m	h	m	Range	Remarks
D	11	21	11	54	41′.2	
H	11	32	11	14*	200γ*	*Estimated, as trace went off sheet.
Z	11	20	11	52	265γ	

According to information received from the Deputy Postmaster General at Perth:

"On the 15th of December, 1919, the telegraph system was again adversely affected by earth currents. At 1 a. m. a maximum of 4 milliamperes in one direction only was noticeable on some telegraph lines running east and west. The value of earth currents increased during the day, at $11^h\ 30^m$ being as high as 40 milliamperes and slowly alternating."

Greenwich mean civil time is used throughout.

Edward Kidson,
Observer-in-Charge.

THE MAGNETIC STORM OF AUGUST 11–12, 1919, AS RECORDED AT BUITENZORG, JAVA.

The conditions prior to the appearance of the storm were those of a magnetically quiet day.

Sudden Commencement. Time, Aug. 11, $6^h\ 58^m.5$ G.M.T.; *X* increases sharply by 165γ; *Y* swings to the west (faintly), to the east (declination 1′), and to the west (declination 7′); and *Z* increases sharply by 29γ.

First Period, $6^h\ 58^m.5$—13^h. Greatest phase of the storm; and *X*, large depression. *X* slowly decreases until 8^h, then rapidly falls; the traces of the two mirrors leave the sheet at $8^h\ 56^m$ and $9^h\ 15^m$, respectively, and return at $11^h\ 50^m$ and $12^h\ 52^m$; the range of this depression probably exceeds 600γ. *Y* rises to a maximum at $9^h\ 20^m$ (the declination being 11′ to eastward of its amount before the storm began). *Z* slowly decreases until $8^h\ 5^m$ (53γ below the undisturbed value at the beginning of the storm), afterwards rapidly rises to a maximum at $10^h\ 9^m$, the total range being 241γ.

Second period, 13^h—17^h. Large and rapid oscillations in the three components. X remains depressed; secondary minimum at $15^h\ 28^m$ (290γ below the initial undisturbed value); secondary maximum at $15^h\ 54^m$; difference of these extreme values 228γ. Y, minimum at $15^h\ 51^m$ (declination $16'.5$ west of the initial undisturbed value); Z, maximum at $15^h\ 54^m$.

Third period, 17^h—24^h. Slowly returning of the magnets to their mean positions, as is characteristic for most storms. X increases gradually with numerous oscillations. Y resumes its normal level at 20^h. Z curve is pretty quiet.

Fourth period, Aug. 12, 0^h—$8^h\ 45^m$. Disturbance apparently enhanced anew. X, minimum at $0^h\ 56^m$; maximum at $2^h\ 54^m$; range, 195γ. Y, rapid oscillations. Z, mean value first increasing, afterwards diminishing.

Fifth period, $8^h\ 45^m$—14^h. Small oscillations.

Sixth period, 15^h—19^h. Activity distinctly enhanced.

End, 19^h. The storm ends rather abruptly at 19^h, Aug. 12.

ROYAL MAGNETICAL AND METEOROLOGICAL OBSERVATORY,
BATAVIA, JAVA. S. W. VISSER,

SONNENTAETIGKEIT, SONNENSTRAHLUNG, LUFTTEMPERATUR UND ERDMAGNETISCHE AKTIVITAET IM VERLAUF EINER SONNENROTATION.

VON G. ANGENHEISTER.

(Vorläufige Mitteilung.)

Zusammenhänge zwischen der Sonnentätigkeit einerseits und der Sonnenstrahlung, Lufttemperatur und Erdmagnetismus andererseits sind zweifellos vorhanden. Es ist jedoch noch nicht zweifelsfrei festgestellt, wie diese Zusammenhänge physikalisch zu erklären sind, und ob gesteigerter Sonnentätigkeit immer erhöhte oder erniedrigte Sonnenstrahlung, Lufttemperatur und erdmagnetische Feldstärke entspricht. Nach Abbot deuten die Solarkonstantenmessungen von Mt. Wilson darauf hin, dass in der elfjährigen Periode eine gesteigerte Sonnentätigkeit von einer gesteigerten Sonnenstrahlung. begleitet ist.[1] Die Lufttemperatur der Erde ist zur Zeit gesteigerter Sonnentätigkeit niedriger. Wir hätten nach Abbot also zur Zeit erhöhter Sonnentätigkeit und Sonnenstrahlung erniedrigte Lufttemperatur auf der Erde. Es liesse sich dies vielleicht erklären durch ein zu dieser Zeit erhöhtes Albedo der Erde, durch eine verstärkte Cirrenschicht, die die Sonnenstrahlung stärker rückstrahlt. Tatsächlich wurde zur Zeit der Maxima der Sonnentätigkeit eine Zunahme der Cirrenhäufigkeit beobachtet und eine quantitative Ueberlegung an der Hand des Stefan-Bolzmannschen Strahlungsgesetzes zeigte mir, dass die hierdurch gesteigerte Rückstrahlung sehr wohl die Abnahme der effectiven Lufttemperatur der Erde erklären könnte.

Um die Frage nach diesem Zusammenhang zwischen Sonnentätigkeit, Strahlung, Lufttemperatur und Erdmagnetismus näher zu untersuchen, schien es mir vorteilhaft, statt der elfjährigen Periode der Sonnentätigkeit die etwa 26½tägige synodische Periode der Sonnenrotation zu Grund zu legen.

Besonders günstig für diese Untersuchung erwiesen sich Zeiten geringer Sonnentätigkeit, wo der grösste Teil der Sonne von Flecken und Fackeln frei erschien, und die Centren gesteigerter Tätigkeit (Flecken etc.) sich auf relativ geringen Raum der Sonnenoberfläche zusammendrängten. Dieser Umstand ermöglichte es, mehrere Rotationen hindurch diese Centren und etwaige Wirkungen derselben zu verfolgen.

[1]Im Gegensatz hierzu war nach Bigelow im Fleckenmaximum 1917 die Solarkonstante nach Messungen in Quiaca und Cordoba kleiner als im Minimum 1913.

I. Methode der Vergleichung.

(*a*) *Mass der Sonnentätigkeit.*

Als Mass für die Tätigkeit des unteren Niveau der Sonnenatmosphäre sind die Sonnenfleckenrelativzahlen für einen jeden Tag (nach Wolfer, *Meteorologische Zeitschrift*) oder die relativen Areale der Flecken (nach *Bol. mens. del Obs. del Ebro*) geeignet; für das obere Niveau die relativen Areale der Floculi für einen jeden Tag nach den spektroheliographischen Sonnenaufnahmen im Observarium del Ebro (*Bol. mens.*) oder in Mt. Wilson. (Diese letzteren wurden mir bei meiner Anwesenheit in Mt. Wilson, Juli, 1913, freundlichst zur Verfügung gestellt.) Die Fleckenrelativzahlen und die Floculiareale summieren über die ganze uns zugekehrte Sonnenhälfte. Während der Jahre 1911/12 war die heliographische Breite der Flecken eine sehr konstante und äusserst geringe, fast alle innerhalb 15°. Um die Lage der Floculi gegenüber dem Centralmeridian der Sonne beim Ausbruch magnetischer Störungen zu untersuchen, wurden die Durchgangzeiten aller Calcium-Floculi von 1911/12 durch den Centralmeridian mit den Störungstagen verglichen.

(*b*) *Mass der erdmagnetischen Aktivität.*

Die erdmagnetische Feldstärke kann man ansehen als Resultante von vier Vektoren; vom Vektor des permanenten innerhalb der Erde gelegenen Feldes E, und den drei Vektoren der in der Atmosphäre gelegenen Felder, nämlich T dem Vektor des täglichen Variationsfeldes, S dem Vektor der Störungen, und A dem Vektor der Nachstörungen. Die drei atmosphärischen Felder T, S, A sind in ihrer geographischen Anordnung und in ihrer physikalischen Bedingtkeit untereinander verschieden. Gemeinsam ist ihnen, dass ihre Stärke mit der ionisierenden Kraft der Sonnenstrahlung schwankt; besonders gilt dies von S und A. Diese beiden sind darum geeignet, Aenderungen der Sonnentätigkeit zu verfolgen. Als Mass für S ist die Aktivität $\left(\frac{f}{T}\int_0^T v^2dt\right)$ nach Bildlingmaier oder die internationale Characterzahl geeignet; beides sind Energiedichten von nahe gleichem zeitlichen Verlauf. Als Mass für die Veränderlichkeit von A können besonders für Stationen niederer Breite die Tagesmittel der Horizontalintensität dienen, in denen der Vektor der täglichen Variation T und zum grössten Teil auch der Störungsvektor S eliminiert ist. Der Vektor A verläuft wohl für die ganze Erde ähnlich, jedenfalls für Stationen mittlerer und

niederer Breite. Für niedere Breiten ist die Schwankung von A am stärksten. Bald nach Eintritt einer Störung steigt A plötzlich an und verschwindet langsam erst nach mehreren Tagen. Die Horizontalintensität und ihr Tagesmittel bewegen sich umgekehrt, sinken plötzlich und kehren langsam zum Normalwert zurück, der oft erst nach vielen Tagen erreicht wird. Als Mass für die erdmagnetische Wirkung der Sonnentätigkeit wurde somit gewählt, für die erste Hälfte von 1911, die Aktivität von Wilhelmshaven (nach den Ergebnissen d. magn. Beobachtungen Wilhelmshaven 1911, Neue Folge Heft 2); ferner für die anderen Jahre die internationalen Characterzahlen im Mittel aller Stationen der Erde. Zum Vergleich des Vektors A wurden die Tagesmittel der Horizontalintensität in Apia, in Honolulu, und Tucson, Arizona, benutzt.

(c) *Mass für die Sonnenstrahlung.*

Von den meteorologischen Elementen kann man wohl am ehesten bei der Maximumtemperatur der Luft einen Einfluss der Sonnentätigkeit erwarten, und zwar um so mehr, je einfacher die meteorologischen Verhältnisse des Ortes sind, und je weniger sie durch Bewölkung und Regen compliciert werden. Es wurden daher 5 Wüstenstationen aus Egypten und dem Sudan, ferner 5 Stationen (Wüsten- oder Gebirgsstationen) aus dem Westen der Vereinigten Staaten von Amerika ausgewählt. Auch die aktinometrischen Messungen von Heluan, Egypten, wurden untersucht.

Das direkte Mass für die Sonnenstrahlung bilden natürlich die Solarkonstantenmessungen. Es wurden die Messungen der 2000^{m} hoch gelegenen Station Mt. Wilson in Südkalifornien verwendet.

TABELLE 1.

Stationen	Breite	Länge	Höhe	Bewölkung Jahresmittel	Regen Jahresmenge	Regentage Zahl
AFRICA—	°	°	m		mm	
Dakhla Casis	25 N	29 E	130	0.5	0	0
Wadi Halfa	22	31	128	0.6	0	0
Atbara	18	34	355	0.6	141	8
Kartoum	16	33	390	1.5	76	13
Gallabat	13	36	767	3.7	809	100
AMERICA—	°	°	Fuss.			
Border	41 N	110 W	6085	...	...	...
Summit	39	121	7017	...	...	...
Santa Fé	36	106	7013	...	...	...
El Paso	32	106	1100	...	...	...
Tucson	32	111	700	...	...	...

II. Resultate der Beobachtung.

Est ist nun zu erwarten, dass die Ursache eventueller Schwankungen in den verschiedenen hier zu untersuchenden Vorgängen der Sonnentätigkeit, des Erdmagnetismus, der Sonnenstrahlung und der Lufttemperatur nicht im selben Sonnenniveau ihren Sitz haben und sich daher mit verschiedener Rotationsdauer wiederholen; es musste deshalb zunächst eine angenäherte mittlere Rotationsdauer gewählt werden. Nach angestellten Versuchen schien 26½ Tage die geeigneteste Zeit zu sein.

Die oben erwähnten Relativzahlen, Temperaturen etc., wurden nun nach 26 oder 27tägigen Perioden geordnet. Die Temperaturen wurden von ihrem jahreszeitlichen, die Horizontal-Intensität von ihrem säcularen Gang befreit; dann wurden mehrere aufeinander folgenden Rotationen übereinander gelagert und zu einer mittleren Periode vereinigt. Doch wurden nicht mehr als 6 Perioden zusammengefasst, damit eine Ungenauigkeit in der Periodenlänge nicht zu grossen Einfluss gewinnen konnte. Auch erhält sich eine gegebene Verteilung der aktiven Centren der Sonnentätigkeit auf ihrer Oberfläche kaum länger. Und gerade eine solche Verteilung z. B., in eine fleckenreiche und eine fleckenarme Sonnenhälfte ist unserer Untersuchung so sehr günstig. Es wurden Zeiten geringer Sonnentätigkeit und stark gestörte untersucht. Besonders geeignet erwiesen sich beide Halbjahre 1911 and die II. Hälfte 1915 und 1916. In diesen Jahren zeigte sich eine wohl ausgesprochene Sonnenrotationsperiode von etwa 26½ Tagen in den Flecken- und Floculiarealen und Relativzahlen; ebenso in den magnetischen Characterzahlen und der Horizontal-Intensität. Für 1911 auch in den Lufttemperaturen; für 1915 fehlten mir die entsprechenden Beobachtungsdaten der Lufttemperatur. Für die afrikanischen Stationen sind sie noch nicht veröffentlicht. Für die amerikanischen Stationen waren sie mir zur Zeit nicht zugängig; zum Ersatz wurden Maximum-Temperaturen von del Ebro untersucht. Sie zeigten jedoch nur eine wenig ausgesprochene Periode. Die Solarkonstantenmessungen zeigten 1911 keine deutliche Periode, wohl dagegen 1915 und 1916. Für 1915 hat Abbot sie schon mit Hülfe des Correlationskoefficienten festgestellt.

Die verschiedenen Jahre zeigen nun zwar zweifelsfrei, dass zu gewissen günstigen Zeiten in der Sonnenstrahlung, Lufttemperatur und Erdmagnetismus periodische Schwankungen von der ungefähren Länge der synodischen Sonnenrotation für die Breite des Sonnenaequators vorhanden sind. Sie zeigen aber andererseits, dass diese Schwankungen nicht in einer konstanten Beziehung zu

der Lage der Sonnenflecken und Fackeln auf der Sonnenoberfläche stehen, etwa in der Weise, dass die Strahlung oder Lufttemperatur oder erdmagnetische Ruhe immer am grössten ist, wenn uns die an Flecken und Fackeln ärmere Sonnenhälfte zugekehrt ist.

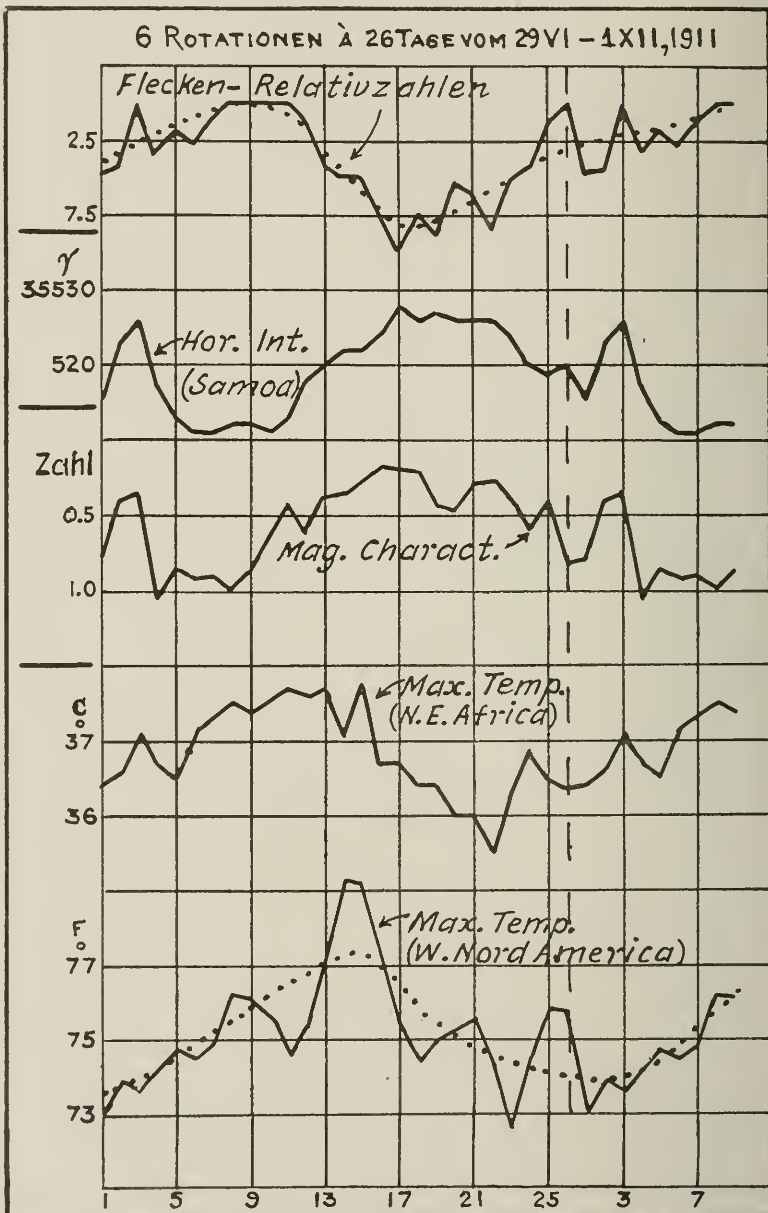
(a) Erdmagnetismus.

Es ergab sich vielmehr, dass im Verlauf einer Rotation 1911 der fleckenärmeren Sonnenhälfte die grössere, 1915 die geringere erdmagnetische Gestörtheit entsprach, während 1916 das Maximum der erdmagnetischen Gestörtheit dem Fleckenmaximum um etwa ¼ Periodenlänge voraneilte. Man kann demnach Flecken (Fackeln) und magnetische Störungen nicht derart einander zuordnen, dass jedesmal beim Passieren eines Fleckes (Fackel) durch einen bestimmten Sonnenmeridian eine magnetische Störung hervorgerufen wird. Es scheint vielmehr, dass die Störungsquelle auf der Sonne, mag sie auch immerhin zunächst von einem Flecke ausgehen und gleichzeitig mit ihm entstehen, sich späterhin in höhere Schichten der Sonnenatmosphäre verlegt und sich dort viele Rotationen hindurch erhält. Infolge der grösseren Rotationsgeschwindigkeit dort eilt sie den tiefer liegenden Flecken voraus und verschiebt sich so in fleckenärmere Gegenden. 1911 waren zweifellos die magnetischen Störungen am häufigsten, wenn uns die fleckenärmere Sonnenhälfte, oft ganz fleckenfrei, zugekehrt war. Die Zahl der Durchgänge der Floculi durch den Centralmeridian der Sonne war 1911 und 1912 am kleinsten, wenn die Störungen am häufigsten waren. Die Störungsquellen waren damals wohl kaum noch die Flecken oder Fackeln. Die Störungsquellen auf der Sonne wenigstens im Jahre 1911 scheinen danach den bisherigen photographischen und spektroheliographischen Aufnahmen zu entgehen.

(b) Sonnenstrahlung.

Zur Zeit, da uns im Verlauf der Rotationen die fleckenärmere Sonnenseite zugekehrt war, zeigte die Solarkonstante 1915 die höheren (+2%), 1916 die geringeren Werte (−1%). Die Periode ist jedoch nicht so ausgesprochen wie beim Erdmagnetismus. Auch ist das vorliegende Material für solche Fragen noch recht lückenhaft. Es scheint nach den vorliegenden Beobachtungen, dass die verminderte Strahlung der Fleckenareale nicht für eine Schwankung der Solarkonstante verantwortlich ist. Dies ist auch von vorneherein nicht zu erwarten, da selbst bei 50% Abnahme der Sonnenstrahlung in den Fleckenarealen selbst bei dem grössten Fleckenmaximum kaum ein $\frac{1}{10}$% Abnahme der Solarkonstante zu erwarten wäre. Die Amplitude der beobachteten 26½tägigen

Schwankung betrug aber 1—2%. Da einmal die an Flecken und Fackeln ärmere Sonnenhälfte als die wärmere erscheint, ein andermal als die kältere, so kann man die Ursache dieser Schwankungen wohl nicht direkt in den Flecken und Fackeln suchen.



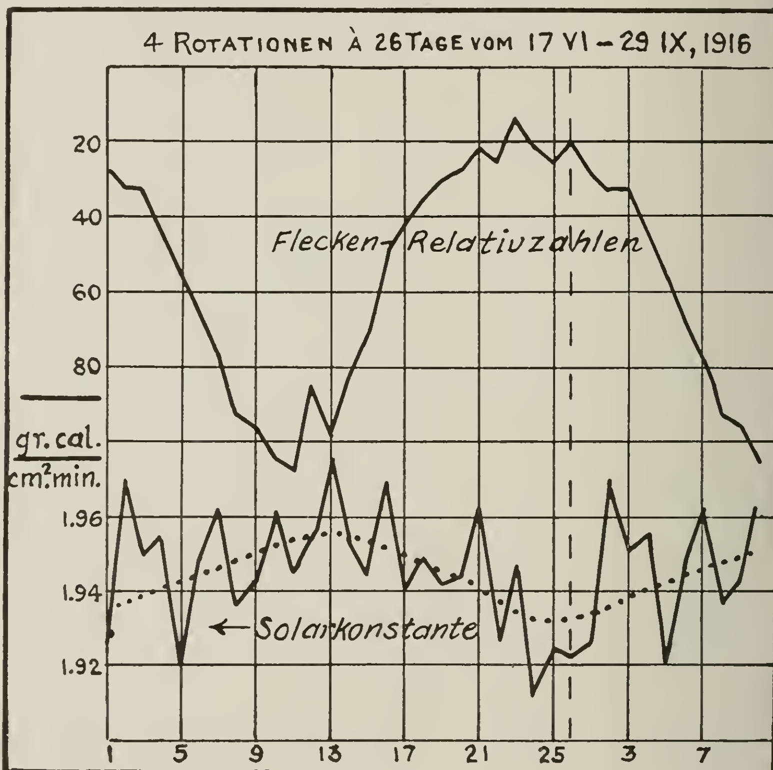
FIGUR 1.

FIGUR 2.

(c) *Lufttemperatur.*

Eine gute ausgesprochene Periode der Lufttemperatur war 1911 vorhanden. Das Maximum der Temperatur trat an den afrikanischen Stationen ein, wenn uns die fleckenärmere Sonnenhälfte zugekehrt war; an den amerikanischen einige Tage später. Leider zeigte die Solarkonstante 1911 keine genügend deutlich ausge-

sprochene 26½tägige Periode. 1915 zeigte die Lufttemperatur von del Ebro eine weniger gut ausgesprochene 26½tägige Periode von etwa 1½°C Amplitude. Das Maximum der Lufttemperatur lag einige Tage später als das Minimum der Flecken (wie 1911) und das Maximum der Solarkonstanten. Die Amplitude der gleichzeitigen Schwankung der Solarkonstanten betrug etwa 2%. Nach dem Stefan Bolzmannschen Gesetze $I = \delta\ T^4$ würde dem etwa



FIGUR 3.

eine Aenderung der effektiven Lufttemperatur der Erde von etwa 1°C entsprechen. Die Schwankung der Lufttemperatur liesse sich also wohl durch die der Strahlung erklären; auch ist die mehrtägige Verzögerung des Maximums der Temperatur gegenüber dem der Strahlung leicht erklärbar.

Die Tabelle gibt die genaueren Zahlenwerte für die Schwankungen während der 26½tägigen Sonnenrotationsperiode. Zum Vergleich sind einige Zahlenwerte aus der 11jährigen Periode der Sonnentätigkeit beigefügt.

TABELLE 2.

Differenzen zwischen den Werten zur Zeit des Fleckenmaximums und Minimums.

	26½tägige Periode der Sonnenrotation			11jährige Periode der Sonnentätigkeit		
	A–B 1911	A–B 1915	A–B 1916	C–D 1893–1901	C–D 1906–1913	C–D 1917–1918
Flecken-Relativzahlen nach Wolfer........	+12	......	+100	+85	+50	+98
Flecken-Areale in $\frac{1}{1000000}$ d. Hemisph. nach del Ebro...........	....	+70	......	....	....	+117
Floculi-Areale in $\frac{1}{10000}$ d. Hemisph. nach del Ebro...........	....	+40	......	....	....	+98
Magn. Charact........	−0.7	+1.0	+0.3	....	+0.2	+0.2
Hor.-Intensität in Gamma = 10^{-5} c.g.s..	+18	−27	+20	....	....	....
Solarkonstante in gr. cal cm² min nach Mt. Wilson.............	−0.02?	−0.04	+0.02	....	+0.03	....
Solarkonstante nach Cordoba und Quiaca.	....	......	......	....	....	−0.15
Max.-Temp. in C°NE Africa..............	−1.9	......	......	−0.9	....	....
Max.-Temp. in C° del Elbro..............	?	−1.5?	......	....	....	−0.3
Max.-Tem. in C° Samoa	?	?	......	−0.8	−1.0	−1.1

Bemerkungen.

A—mittleres Tagesmittel zur Zeit des Fleckenmaximums im Verlauf der Sonnenrotation.

B—mittleres Tagesmittel zur Zeit des Fleckenminimums im Verlauf der Sonnenrotation.

C—Jahresmittel zur Zeit des Fleckenmaximums im Verlauf der 11jährigen Periode.

D—Jahresmittel zur Zeit des Fleckenminimums im Verlauf der 11jährigen Periode.

? bedeutet, dass die Periode nicht klar ausgesprochen ist.

Wenn die Extreme nicht mit denen der Sonnentätigkeit zusammenfallen, so ist das Vorzeichen fortgelassen.

Die Lücken sind entstanden, weil bisher kein Beobachtungsmaterial dieser Zeit veröffentlicht, oder mir hier nicht zugänglich war.

Als Ergebnis dieser Untersuchung lässt sich aussprechen: Sonnentätigkeit, Sonnenstrahlung und Erdmagnetismus zeigen periodische Schwankungen von 26 bis 27 Tagen Länge, also von der Länge der synodischen Rotationszeit der Sonne im Sonnenaequator. Die Phasen der Schwankungen in der Sonnenstrahlung und dem Erdmagnetismus stehen jedoch in keiner konstanten Beziehung zu den Eintrittszeiten der Extremwerte der Sonnentätigkeit gemessen an Flecken und Fackeln. Die Flecken und Fackeln auf der Sonnenoberfläche sind daher wohl kaum die unmittelbare Ursache der etwa 26½tägigen periodischen Schwankung in der Sonnenstrahlung und dem Erdmagnetismus.

UEBER DIE FORTPFLANZUNGS-GESCHWINDIGKEIT ERDMAGNETISCHER STOERUNGEN UND PULSATIONEN.

(Auszug aus den Berichten über die erdmagnetische Schnell- und Feinregistrierung in Apia, Batavia, Cheltenham und Tsingtau im September 1911 und Oktober 1912.)

Von G. Angenheister.

Die Aufgabe der erdmagnetischen Beobachtung ist eine zweifache: Erstens die Ermittelung der geographischen Verteilung des erdmagnetischen Feldes durch eine magnetische Vermessung der Länder und Meere. Landesvermessungen und besonders die zahlreichen Expeditionen und Seereisen dienen diesem Zwecke. Die zweite Aufgabe ist die Verfolgung der zeitlichen Veränderungen dieses erdmagnetischen Feldes durch fortlaufende photographische Registrierungen der erdmagnetischen Elemente, die durch absolute Messungen kontrolliert werden. Ein Netz von erdmagnetischen Observatorien, verbreitet über die ganze Erde, sucht dies zu erfüllen.

Die erste Aufgabe, die Vermessung, erfuhr in den letzten 15 Jahren eine ausserordentliche Förderung in den zahlreichen Landexpeditionen und Seereisen, die durch die Carnegie Institution zu Washington ausgeführt wurden. Der besondere Zweck derselben war, für die unvermessenen und nur unsicher erforschten Länder und Meere die nötigen Beobachtungen zu beschaffen. In den nächsten Jahren wird diese gründliche Vermessung der gesamten Erde im allgemeinen vollendet sein.

Die Verteilung der erdmagnetischen Observatorien, die der zweiten Aufgabe, der zeitlichen Verfolgung des erdmagnetischen

Feldes, dienen, ist eine sehr inhomogene; dicht gedrängt in Kulturländern; der übrige Teil der Erde, besonders die Südhalbkugel, dagegen ist arm an erdmagnetischen Observatorien. Es ist das nächste Ziel, diese Verteilung homogener zu gestalten, besonders durch Neugründungen auf der Südhalbkugel. Dies ist daher auch in dem Arbeitsprogramm der Carnegie Institution enthalten, die in den letzten Jahren bereits zwei Observatorien auf der Südhalbkugel gegründet hat, nämlich Watheroo in Australien und Huancayo in Peru.

Die praktische erdmagnetische Forschung beschafft so die Beobachtungsdaten für die geographische Verteilung und zeitliche Veränderung des erdmagnetischen Feldes. Das Ziel der theoretischen Forschung ist, auf Grund dieser Beobachtungen die Verteilung und zeitliche Veränderung des Feldes physikalisch zu erklären.

Im allgemeinen richtet sich die praktische Forschung bei der Anordnung ihrer Beobachtungen nach den Wegen und Zielpunkten, die die theoretische Forschung als am besten gangbar und als erstrebenswert vorzeichnet. Für besondere theoretische Ziele müssen zuweilen besondere Beobachtungsmethoden gewählt werden. Schwierig ist es dann oft, eine genügende Anzahl geeignet verteilter Observatorien für einen solchen besonderen Beobachtungsplan zu gewinnen. Zu grossem Dank weiss ich mich daher auch dafür verpflichtet, dass mir das Entgegenkommen von drei Observatorien die Arbeit, über die hier berichtet wird, ermöglicht hat.

Die theoretische erdmagnetische Forschung hat uns auf Grund des vorliegenden Beobachtungsmaterials gelehrt, dass das erdmagnetische Feld durch die Uebereinanderlagerung vier verschiedener Felder entsteht, von denen jedes seine besondere geographische Anordnung und zeitliche Veränderung besitzt, und auch wohl seine besondere physikalische Bedingtheit: das permanente innerhalb der Erde gelegene Feld E und die drei vorwiegend in der Atmosphäre gelegenen Felder, nämlich das tägliche Variationsfeld T, das Störungsfeld S, das Nachstörungsfeld A. In der Verfolgung der zeitlichen Aenderung des Gesamtfeldes traten uns die Aenderungen der vier Partialfelder in den bekannten Erscheinungen des säkularen Ganges (E), des täglichen Ganges (T), der Störung (S) und der Nachstörung (A) entgegen. Mit dem Störungsfeld (S) wollen wir uns hier beschäftigen.

Die Störungen sind Abweichungen, oftmals plötzliche und sehr bedeutende von dem Normalzustand des permanenten und täglichen Feldes. Ihre Häufigkeit zeigt Perioden, die mit der der Erdrotation

(tägliche), der Sonnenrotation (etwa 26tägige) und der Sonnentätigkeit (etwa 11jährige) sehr gut übereinstimmen. Es kann darum kaum ein Zweifel darüber bestehen, dass die Störungen von der Sonnentätigkeit veranlasst werden. Trotzdem dieser Zusammenhang der Störungen mit der Sonnentätigkeit bei der Mittelbildung über längere Zeiträume recht einwandsfrei hervortritt, so ist es doch nicht gelungen, die einzelnen Störungen besonderen Vorgängen auf der Sonne zuzuordnen; z. B., eine bestimmte Störung einem bestimmten Sonnenfleck oder Fackel, oder einem bestimmten Stadium in der Entwicklung derselben, oder einer bestimmten Lage derselben gegenüber dem Zentralmeridian der Sonne. Es ist darum trotz mancher Versuche auch noch nicht gelungen, die für die physikalische Erklärung so wichtige Zeit zu ermitteln, die zwischen dem die Störung erzeugenden Vorgang auf der Sonne und dem hier auf der Erde oft so markanten Beginn einer Störung vergeht; d. h., die Fortpflanzungsgeschwindigkeit im intraplanetaren Raum. Es ist nun mehrfach versucht worden, mit Hülfe der üblichen langsamen photographischen Registrierungen das Fortschreiten des Störungsbeginnes über die Erde von einer Beobachtungsstation zur anderen zu verfolgen. Es bildeten sich dabei zwei Ansichten heraus, die eine glaubt, dass in etwa 7 min. sich die Störungen rund um die Erde fortpflanzen, bald ost-, bald westwärts. Die andere glaubt, dass die Geschwindigkeit zu gross sei, um mit den üblichen Registrierungen eine Differenz in der Zeit des Eintreffens der Störung an verschiedenen Observatorien zu ermitteln.

Eine zuverlässige Bestimmung der Fortpflanzungsgeschwindigkeit würde uns der physikalischen Erklärung der Störungen erheblich näher bringen.[1] Auf Veranlassung von L. A. Bauer wurden von 32 Observatorien die Zeit der plötzlichen Anfangsphasen von den 15 grössten Störungen der Jahre 1906–9 nach den üblichen langsamen Registrierungen im Terr. Magnetism 1911 veröffentlicht.

Ich ermittelte aus diesem Material für einen Umlauf um die Erde, im Mittel etwa 2 min.,vielleicht sind auch diese 2 min. auf die Unsicherheit der Beobachtung zurückzuführen, auf eine zu langsame Registriergeschwindigkeit und auf die Schwierigkeit, dieselbe Anfangsphase an verschiedenen Orten zu identificieren. Um durch besseres Beobachtungsmaterial die Frage zu entscheiden,

[1] Siehe: C. CHREE, Supposed Propagation of equatorial magn. disturbances, *Proc. Phys. Soc.*, London, XXIII. Dec. 15, 1910.

L. A. BAUER and R. L. FARIS, *Terr. Magn.*, XV, S. 9, 93, 219. 1910.

VAN BEMMELEN, *Appendix to Observations at Batavia*, XXIX. 1906.

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ANGENHEISTER: I Teil dieses Berichtes, *Nachr. d. Kgl. Ges. d. Wiss. Göttingen*. 1913.

erbat ich die Mitwirkung der Observatorien von Batavia, Cheltenham (bei Washington) und Tsingtau zu einer Schnell- und Feinregistrierung für September 1911 und für Oktober 1912. Die Verarbeitung dieses Beobachtungsmaterials ergab jedoch sehr wenig markante Störungsanfänge, so dass die Frage der Fortpflanzung der Störungsanfänge hierdurch nicht gefördert werden konnte.

Dagegen enthielten die gemeinsamen Registrierungen eine grosse Anzahl gut ausgebildeter Pulsationen. Dies sind sehr regelmässige sinusförmige Schwingungen von etwa 0.2–2 min. Periode und einigen Gamma ($10-^5$ Gauss) Amplitude. Der Beginn eines solchen Wellenzuges und die Umkehrpunkte sind oft sehr markant, und daher sehr geeignet zum Studium der Fortpflanzungsgeschwindigkeit dieser Störungsart. Für die Genauigkeit der Zeitangaben ist vor allem die Registriergeschwindigkeit massgebend. Aber auch der Gang der Registrieruhr, die Häufigkeit der Zeitmarken und die Feinheit und Empfindlichkeit der Registrierung. Aus allen zusammen wurde die Genauigkeit der Zeitangabe geschätzt.

TABELLE 1.

Observatorium	Registrierungsgeschwindigkeit		Genauigkeit		Empfindlichkeit 1912 in Gamma/mm		
	1911 mm/min.	1912 mm/min.	1911 sec.	1912 sec.	Decl.	Hor. I	Vert. I
Apia	1.5	4	±10	±5	0.7	0.7	0.5
Batavia	4	3.8	2	2½	0.4	0.4	......
Cheltenham	1	1	30	30	2.4	6.0	5.4
Tsingtau	1	1	15	18	0.7	4.0	6.0

An der Hand der Kurven wurden nun Pulsationen mit scharfen Umkehrpunkten von 1—2 min. Periode auf den Registrierungen der 4 Observatorien hervorgesucht und die Eintrittszeiten dieser leicht identificierbaren Phasen bestimmt und die Differenz dieser Eintrittszeiten für die verschiedenen Stationspaare berechnet. Eine beträchtliche Anzahl gut ausgebildeter Pulsationen wurde benutzt. Die aus ihnen gewonnenen Differenzen der Ankunftszeiten für jedes Stationspaar zu einem Mittelwert vereinigt und der mittlere Fehler dieses Mittels berechnet.

Andererseits wurde aus der geschätzten Genauigkeit der Zeitangabe, nach der Fehlertheorie, der geschätzte mittlere Fehler einer einzelnen Zeitdifferenz für ein Stationspaar berechnet und ferner

der mittlere geschätzte Fehler für das Mittel aller für dieses Stationspaar ermittelten Zeitdifferenzen. Mit diesem „geschätzten" mittleren Fehler konnte dann der direkt aus den Beobachtungen gewonnene „beobachtete" mittlere Fehler verglichen werden.

TABELLE 2.

Observatorien	Jahrgänge	Zahl der Beobacht.	Mittlere Differz. der Ankunftszeit	Mittlerer Fehler des Mittels	
				beobacht.	geschätzt
Ba–Ts.........	1911	10	-5.8^s	$\pm 4.2^s$	$\pm 4.7^s$
	12	16	−0.8	3.6	4.6
	1911/12	26	−2.7	2.6	3.3
Ba–Ap........	1911	7	−0.8	5.1	3.8
	12	11	+5.9	2.0	1.8
	1911/12	18	+3.3	2.2	1.6
Ts–Ap.........	1911	9	+9.4	4.5	6.0
	12	15	+2.5	3.1	4.8
	1911/12	24	+5.1	2.6	3.7
Ts–Ch.........	1911	3	+14.7	12.7	16.8
	12	4	−25.1	10.4	20.6
	1911/12	7	−6.6	12.9	13.8
Ap–Ch........	1911	5	+18.9	7.4	14.4
	12	5	−13.6	13.4	15.3
	1911/12	10	+2.6	8.9	10.5

Die ersten 3 Stationspaare geben im Mittel 1911/12 Werte, die nicht viel grösser als die beobachteten und geschätzten mittleren Fehler sind.

Die Bedingungsgleichung Ba—Ts = Ba—Ap—(Ts—Ap) ist nicht genau erfüllt. Es liegen für eine bestimmte Pulsation nicht immer von allen Stationen Beobachtungen vor. Ein Ausgleich nach der Methode der kleinsten Quadrate führt zu den wahrscheinlichsten Werten.

$$\begin{aligned} \text{Ba} - \text{Ts} &= -\ 2.4^s \pm 2.6^s \\ \text{Ba} - \text{Ap} &= +\ 3.0\ \ \pm 2.2 \\ \text{Ts} - \text{AP} &= +\ 5.4\ \ \pm 2.6 \end{aligned}$$

Es ist hiernach sehr wenig wahrscheinlich, dass die beobachteten Differenzen reell sind, sondern es ist anzunehmen, dass sie auf Beobachtungsfehlern beruhen.

Der endgültige Bericht über diese gemeinsame Arbeit der vier Observatorien zu Apia, Batavia, Cheltenham und Tsingtau hat

sich durch den Kriegsausbruch bis jetzt verzögert; denn die bisher nur aus Mondkulminationen bekannte Länge von Apia konnte von mir erst im November 1919 durch Funkensignale nachgeprüft werden. Es ergab sich: Apia = $11^h\ 27^m\ 6.7^s$ W.

Die Perioden der benutzten Pulsationen liegen durchweg zwischen 90^s und 120^s, doch wurden auch ein paar kleinere und grössere benutzt. Die Periodenlänge änderte sich von Station zu Station meistens nicht, zuweilen um einige %, nur einmal um nahezu 50%. Die regelmässige Form der Pulsationen hat mehrfach die Vermutung erweckt, dass sie eine Eigenschwingung,—irgend welcher Art,—der Erde als Ganzes oder ihrer Atmosphäre seien von der Periode der Pulsation, also in unserem Falle von $90–120^s$. Die ermittelten Differenzen der Eintrittszeiten an den verschiedenen Stationen,—falls sie überhaupt reell sind,—sind viel zu klein, um einen Anhalt für eine Eigenschwingung zu geben, die in meridionaler oder in aequatorialer Richtung fortschreite, denn die Distanz Batavia–Tsingtau beträgt beinahe ⅛ des Erdumfanges in meridionaler, Batavia–Apia beinahe ¼ in aequatorialer Richtung.

Für eine aequatoriale Eigenschwingung von 100^s müsste die Differenz der Eintrittszeiten der Umkehrpunkte für Ba–Ap $= 25^s$ und Ba—Ts $= 12.5^s$, Beträge, die nach unseren Beobachtungen ausgeschlossen erscheint.

Das Aussehen der Pulsationen an den verschiedenen Stationen zeigte ausserordentliche Aehnlichkeit. So erfolgte selbst bei Stationen, wie Cheltenham und Tsingtau, die etwa 160° Längendifferenz besitzen, das An- und Abschwellen zweier aufeinander folgender Serien von Schwingung in überraschend ähnlicher Weise. Man muss darum wohl annehmen, dass die Form und Periode eines solchen Wellenzuges nur wenig durch die örtlichen Verhältnisse bedingt wird; wohl aber die Intensität: An der Nachtseite der Erde waren die Pulsationen von $1–2^m$ Periodenlänge häufiger und stärker als an der Tagseite. In allen klar ausgeprägten Fällen begannen die Pulsationen an allen Stationen mit einem positiven Anstieg in der Horizontalintensität. Die periodische Bewegung des magnetischen Vektors erfolgte in meridionaler Richtung.

Gleichzeitig mit dem Anfang einer Serie von Pulsationen beginnt, besonders in mittleren und niederen Breiten, sehr oft eine grössere Ausbuchtung der Registrierkurve von ½—1stündiger Dauer. Diese Ausbuchtung ist gewöhnlich einseitig, glatt, der ersten Hälfte einer sinusförmigen Bewegung nicht unähnlich. Die Grössenordnung der Bewegung beträgt für $\triangle H$ etwa 50, für $\triangle D$

etwa 30, für $\triangle Z$ etwa 5 Gamma. Sie wiederholen sich an aufeinanderfolgenden Tagen oft zu nahe gleichen Tagesstunden, besonders zwischen 8 p. m. und 3 a. m. Vermutlich sind diese Ausbuchtungen für mittlere und niedere Breiten die Störungseffecte der für hohe Breiten so typischen Polarstörungen (polarstorms nach Birkeland). Die magnetischen Störungsvektoren dieser Ausbuchtungen waren bei nahezu gleicher Länge der Stationen (Batavia und Tsingtau) bei der polnäheren grösser (Tsingtau). Bei Stationen nahezu gleicher Breite zeigte diejenige die stärkere Bewegung, die dem Mitternachtsmeridian näher lag. An der Nachtseite sind die Störungsvektoren für alle 4 Stationen (2 nördlicher, 2 südlicher Inclination und Breite) nördlich gerichtet, und zwar um so mehr, je mehr die Station der Mitternacht nahe ist. An der Tagseite sind die Vektoren klein, daher oft in ihrer Richtung unsicher, jedoch zweifellos zuweilen nach Süden gerichtet.

Resultate.

Als Resultate der gemeinsamen Schnell- und Feinregistrierung der vier Observatorien, Apia, Batavia, Cheltenham, Tsingtau, lässt sich aussprechen:

(1) Die Differenz der Eintrittszeiten gleicher Phase der Pulsationen an den vier Observatorien ist von der gleichen Grössenordnung wie der mittlere Beobachtungsfehler der Messungen. Die Stationen mit grösster Registriergeschwindigkeit und höchster Empfindlichkeit, Batavia und Apia (fast ¼ Erdumfang Abstand), ergaben:

$$\text{Ba} - \text{Ap} = +3.0^{s} \pm 2.2^{s}$$

Die Pulsationen von 1—2^{m} Periode sind daher wohl keine meridional oder aequatorial verlaufende Eigenschwingungen der Erde oder Atmosphäre.

(2) Sie sind an der Nachtseite der Erde häufiger und stärker. Sie beginnen mit positivem Anstieg in der Horizontalintensität. Der Störungsvektor ist meridional gerichtet.

(3) Die Ausbuchtungen, oft gleichzeitig mit Pulsationen auftretende Störungen, sind für Stationen gleicher Länge an der polnäheren Station stärker; ferner für Stationen gleicher Breite an der am stärksten, die dem Mitternachtsmeridian am nächsten liegt. Der Störungsvektor ist an der Nachtseite stets nördlich gerichtet, an der Tagseite dagegen südlich.

CONCERNING PROCEDURE AT MAGNETIC OBSERVATORIES.

By Charles Chree.

From facts which have come to my knowledge since writing the note which appeared under the above title in the December, 1919, number, it seems to me desirable to amplify the statement made on page 158 that the use of 60-minute mean ordinates tends "to give too small amplitudes for the Fourier waves, especially those of shortest period." This is sufficiently obvious to the mathematician, when the question is presented as a mathematical problem; but it is apt not to suggest itself—I speak from personal experience—to one habituated to the use of the ordinary formulae, and concerned at the moment only with the physical aspect of the case.

Fortunately it is easy to make the necessary allowance. The mathematical aspects are discussed in the British Association Report for 1883, page 98, as part of a report on harmonic analysis drawn up by the late Sir George Darwin. All that is necessary is to apply to the amplitude coefficients, calculated from the ordinary formulae, the following correcting factors (l. c. page 98):

24-hour wave, 1.00286; 12-hour wave, 1.01152; 8-hour wave, 1.02617;
6-hour wave, 1.04720; 4-hour wave, 1.11072: 3-hour wave, 1.20920

The phase angles are unaffected.

If instead of 60-minute means, one employed means from shorter intervals, *e. g.*, 20 minutes, 10 minutes, or 5 minutes centering at the hour, correction factors would also theoretically be necessary, but of so much smaller amplitude as hardly to merit consideration for the first 3 or 4 waves.

Correction factors are also necessary if one takes the mean of 2, 3, or more ordinates for times centering at the hour. Thus if one takes the arithmetic mean of three ordinates, one answering to the hour, the others to times 20 minutes earlier and later, the factor $(1-\frac{4}{3}\sin^2\alpha)^{-1}$ is wanted, where α is $2°.5$ for the 24-hour wave, $5°$ for the 12-hour wave, and so on. The values of these factors for the 24, 12, 8, and 6-hour waves are, respectively, 1.0025, 1.0102, 1.0232, and 1.0419. The necessity for these factors, I regret to add, was overlooked in a publication for which I was personally responsible "National Antarctic Expedition 1901–04, Magnetic Observations." I have reason to believe that I have not been the only one remiss in this line, and it is not improbable that this note may be instrumental in awakening others.

NOTES

1. *Principal Magnetic Storms at Cheltenham Magnetic Observatory, October to December, 1919.*[1]

Greenwich Mean Time								Range		
Beginning				Ending				Declination	Hor'l Int.	Vert'l Int
		h	m			h	m	′	γ	γ
Oct.	1,	16	10	Oct.	2,	3	..	67.5	364	624
Oct.	3,	4	03	Oct.	4,	13	..	23.2	212	191
Oct.	4,	13	..	Oct.	6,	10	..	57.6	299	221
Dec.	15,	1	..	Dec.	15,	22	..	42.8	207	219

2. We are pleased to note the reappearance of *Ciel et Terre*, the bulletin of the Société Belge d'Astronomie. The number at hand, that for December, 1919, concludes the series of 1914–1919. The Society has our best wishes for the prosperous continuance of its valued publication and the steady growth of its work in importance and interest.

3. A new periodical, *Geografiska Annaler*, has been established at Stockholm by the Swedish Society for Anthropology and Geography. The editorial staff consists of Prof. Gunnar Andersson, Axel Wallén, and Hans W. Ahlmann. It is to appear at least four times a year and will contain original articles, brief reviews and notices of books in geography, geophysics, and pure ethnology.

4. *Meteorological Magazine.* This new magazine takes the place of *Symons's Meteorological Magazine*, which terminated with the January, 1920, number; it is issued as the official organ of the Meteorological Office and combines with it the *Meteorological Office Circular.*

5. *Samoa Geophysical Observatory at Apia.* Efforts are being made to ensure the continuation of the valuable work at this favorably-located observatory, possibly under the auspices of the Government of New Zealand; Dr. C. E. Adams, the government astronomer, recently made a visit to Apia to look into the possibilities. During the late war and up to the present time, Dr. *Angenheister*, the observer-in-charge, has zealously continued the work of the Observatory with the aid of funds borrowed from resident Germans. (*Cf.* v. 23, p. 150.)

6. *Royal Belgian Magnetic Observatory at Uccle.* It is recorded with pleasure that the work of the Uccle Observatory suffered no interruption during the late war. (*Cf.* v. 23, 1918, p. 150.)

7. *British Imperial Antarctic Expedition, 1920.* According to a letter received from the Commander of the Expedition, *John L. Cope*, who was a member of the Ross Sea party of the last Shackleton Expedition, it is hoped to leave Eng-

[1] Communicated by E. Lester Jones, Superintendent U. S. Coast and Geodetic Survey; Geo. Hartnell, Observer-in-Charge; Lat. 38° 44.0′ N.; Long. 76° 50.5′ W. or 5h 07.4m West of Greenwich.

land in June. Capt. *George Wilkins*, who was with the Stefansson Canadian Arctic Expedition, will be the Chief of the Scientific Staff. In addition to other scientific work, it is planned to operate a magnetic observatory for about four years at New Harbor and to make field observations for one year at Scott Island, and also to observe the magnetic elements at a series of field stations around the Antarctic coast during four years.

8. *Personalia. Arthur Schuster* was one of the new knights in the list of British new year honors. At the beginning of March, Dr. *Giorgio Abetti* was transferred from the R. Osservatorio Astronomico al Collegio Romano to the R. Osservatorio in Arcetri at Florence. We regret to record the death at Budapest, on April 8, 1919, of Baron R. von Eötvös, the eminent Hungarian geophysicist; also the death of Rear Admiral *Robert Edwin Peary*, in Washington, D. C., on February 20, aged sixty-three years.

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SAN FERNANDO. Anales del Instituto y Observatorio de Marina de San Fernando publicados de orden de la superioridad, por el Director Don Tomás de Azcárate. Sección 2a. Observaciones meteorológicas, magnéticas y sísmicas. Año 1917. San Fernando, 1918 (viii + 166 con fotogramas). 35 cm.

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[Plate II]

DEPARTMENT OF TERRESTRIAL MAGNETISM, WASHINGTON, D. C.

[View of Buildings and Site taken by Dr. W. F. Meggers, of United States Bureau of Standards, from an airplane at about 4,000 feet altitude, December 3, 1919.]

Terrestrial Magnetism and Atmospheric Electricity

VOLUME XXV — JUNE, 1920 — NUMBER 2

RESULTS OF ATMOSPHERIC-ELECTRIC OBSERVATIONS MADE AT SOBRAL, BRAZIL, DURING THE TOTAL SOLAR ECLIPSE OF MAY 29, 1919.[1]

BY S. J. MAUCHLY AND ANDREW THOMSON.

1. In accordance with the general plan of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington for making magnetic and atmospheric-electric observations to determine the nature and magnitude of the respective effects associated with solar eclipses, parties equipped for this purpose were sent by the Department to several points located in the belt of totality of the solar eclipse of May 29, 1919. One of these parties, in charge of Mr. D. M. Wise, proceeded to northeastern Brazil, where it was thought possible, from a consideration of the various factors entering into the matter, to find a suitable location. Fig. 1 shows the general relation of this region to the eclipse and especially to the belt of totality.

LOCATION OF STATION AND LOCAL CIRCUMSTANCES OF ECLIPSE.

2. After considering various sites, it was decided to make the observations at Sobral, latitude 3° 41′.6 S, longitude 40° 20′.8 W, near the middle of the belt of totality (see Fig. 1). The eclipse at Sobral began at $8^h\ 04^m$ L. M. T. ($10^h\ 45^m$ G. M. T.), and ended at $10^h\ 47^m$ L. M. T. ($13^h\ 29^m$ G. M. T.). The duration of totality was 5.3 minutes, mid-totality occurring at $9^h\ 19^m$ L. M. T. ($12^h\ 00^m$ G. M. T., civil).

[1] Presented before the American Physical Society at its meeting in Washington, April 23, 1920. Fuller publication will be made in "Researches of Department of Terrestrial Magnetism", Vol. IV, now in preparation.

3. Sobral is about 90 kilometers from the Atlantic Coast, and its elevation is less than 100 meters. The observations were made in the Prada (Jockey Club inclosure) on the southeastern outskirts of the city. The fact that both the British Astronomical Expedition and the Brazilian Commission had also selected this station proved to be of very great value for the Department's work.

Observations, Apparatus, and Methods.

4. Mr. Wise, besides being in charge of the expedition, had personal charge of the special magnetic observations at Sobral, the results of which will be reported upon elsewhere, while to Mr. Andrew Thomson were assigned the atmospheric-electric observations. In the observational work Mr. Thomson was assisted by Mr. Antonio Lima, a native of Brazil, who had been educated in the United States, and whose faithful and conscientious service contributed largely to the success of the atmospheric-electric work.

5. The atmospheric-electric observations consisted of positive conductivity (λ_+), negative conductivity (λ_-), and the potential gradient (X). The apparatus and method for conductivity observations were in general the same as those employed by the authors at Lakin, Kansas, during the total solar eclipse of June 8, 1918.[2]) That is to say, the observations for λ_+ and λ_- were made almost simultaneously and by a single observer (Mr. Thomson), on two separate instruments (Gerdien Conductivity Apparatus) at intervals of about 2 minutes. As before, both instruments were oriented to receive the prevailing winds, which in the forenoons were mainly from the southeast or land direction, and both were driven by belts from a single jack-shaft (See Fig. 2). A suitable low shelter protected observer and instruments from the sun. A careful comparison of the two instruments was made *in situ* and all conductivity results are given on the basis of the instrument whose constants are most accurately known.

6. In view of the fact that considerable insulation trouble was expected from moisture and from small insects, especially spiders, and because it is not feasible to make leak corrections for potential-gradient observations, it was decided to provide a special insulating support for the ionium collectors used in these observations, and to

[2] *Terr. Mag.*, vol. 24, pp. 22 to 28 and 87 to 98, March and June, 1919.

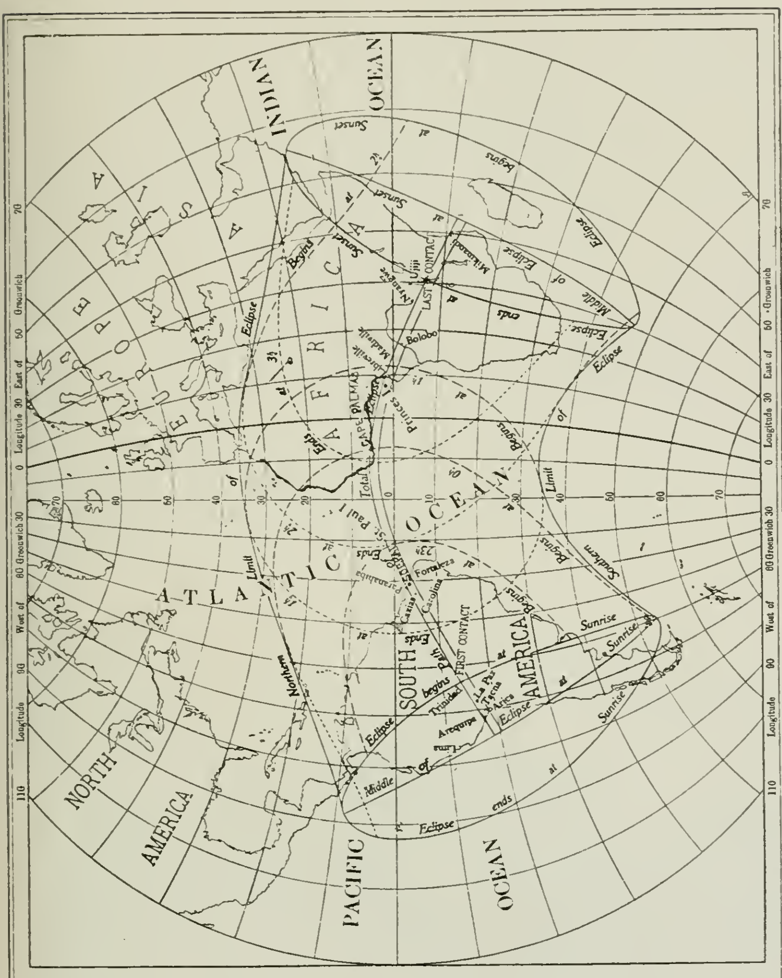

FIG. 1.—THE BELT OF TOTALITY FOR THE SOLAR ECLIPSE OF MAY 29, 1919.

[The hours of beginning and ending are expressed in Greenwich mean time.]

take special measures against insects. The special insulator, with collectors in place, is represented in Fig. 3. At the close of each day's observations the insulator was disassembled, by means of the screw connections at *A* and *B*, and the sulphur support removed and placed in a house during the night. This not only gave opportunity for scraping the surface of the sulphur and renewing the drying materials, but also prevented the accumulation of windborne fibers and the webs of flying insects. The insulator was mounted on a post 1 meter high and 3.5 meters removed from the shelter for observer and (Wulf) electroscope. The post supporting the collectors, and also the legs of the table on which the electroscope was mounted, were girdled with a preparation known as "Tanglefoot" used by orchardists to protect fruit trees against crawling insects. By this means all annoyances from spiders and other insects were avoided, and, although repeated tests were made, the leak was always found to be exceedingly small.

7. The potential-gradient observations were made by Mr. Lima, the electroscope-readings being taken every minute except during the eclipse, from first to last contacts, when they were taken every 30 seconds. The factor for reducing electroscope-readings to volts per meter was determined on the basis of simultaneous observations according to the method described by Simpson and Wright.[3]

[3] *Proc. R. Soc. A.*, vol. 85, p. 182, 1911.

FIG. 2—CONDUCTIVITY APPARATUS AND SHELTER AT SOBRAL.

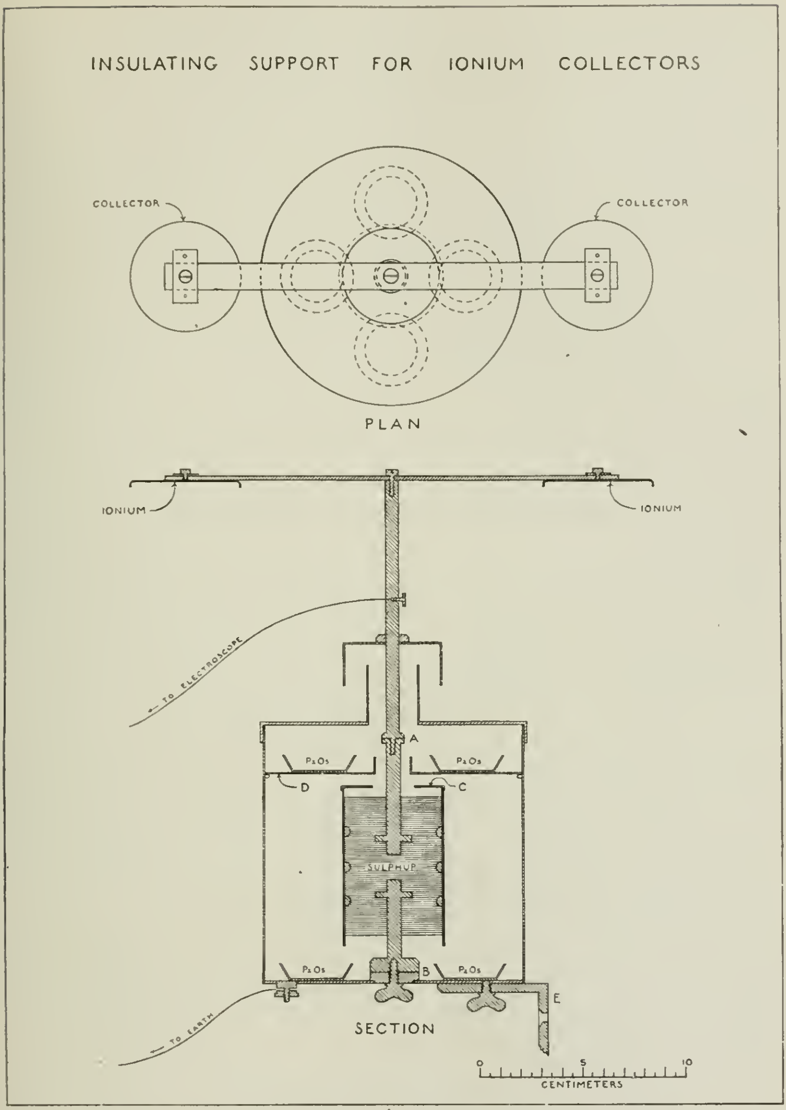

FIG. 3.—INSULATING SUPPORT FOR IONIUM COLLECTORS USED IN POTENTIAL-GRADIENT OBSERVATIONS.

Results of Observations.

8. Regular observations were made hourly, for periods of about 20 minutes, throughout the forenoons from May 24 to June 2, inclusive, except on May 29, when the observations were made as nearly continuously as was consistent with adequate control observations. The results of all the above observations are graphically represented in Fig. 4. It should be noted that each individual observation made on May 29 was plotted on the respective graphs. The broken-line graphs represent the corresponding means of all observations made during the period from May 24 to June 2 except those of May 29.

9. Through the kindness of Dr. Morize of the Brazilian Commission, copies of the sunshine records from a Campbell-Stokes recorder have been made available for the entire period during which observations were made. At the bottom of Fig. 4 is an approximate reproduction of the record for May 29, straightened and adjusted to the time scale of the other observations. According to the record of the observers, there was considerable cloudiness during the early part of the eclipse, with only an occasional glimpse of the Sun for short periods. About 15 minutes before totality the clouds began to drift away, but the obscuration had already become so great that no marked "burn" was recorded until about 15 minutes after totality.

10. No doubt the cloudiness mentioned above is largely responsible for the character of the various curves during the first hour of the eclipse, so that one can scarcely draw safe conclusions from the results for this period. If, however, we direct our attention to the period beginning with $11^h\ 45^m$ G. M. T. we find that the general results may be stated to have been as follows:

(*a*) The potential-gradient showed a well-formed minimum beginning with totality and extending until about 20 minutes after totality. The values observed during this period were about 20 per cent. lower than the mean derived from two equal periods immediately preceding and following it.

(*b*) During the period of potential-gradient minimum the fluctuations of the gradient were very much smaller than during the similar periods preceding and following.

(*c*) The positive and negative conductivities (and, therefore, the total conductivity also) each showed an increase of the order of

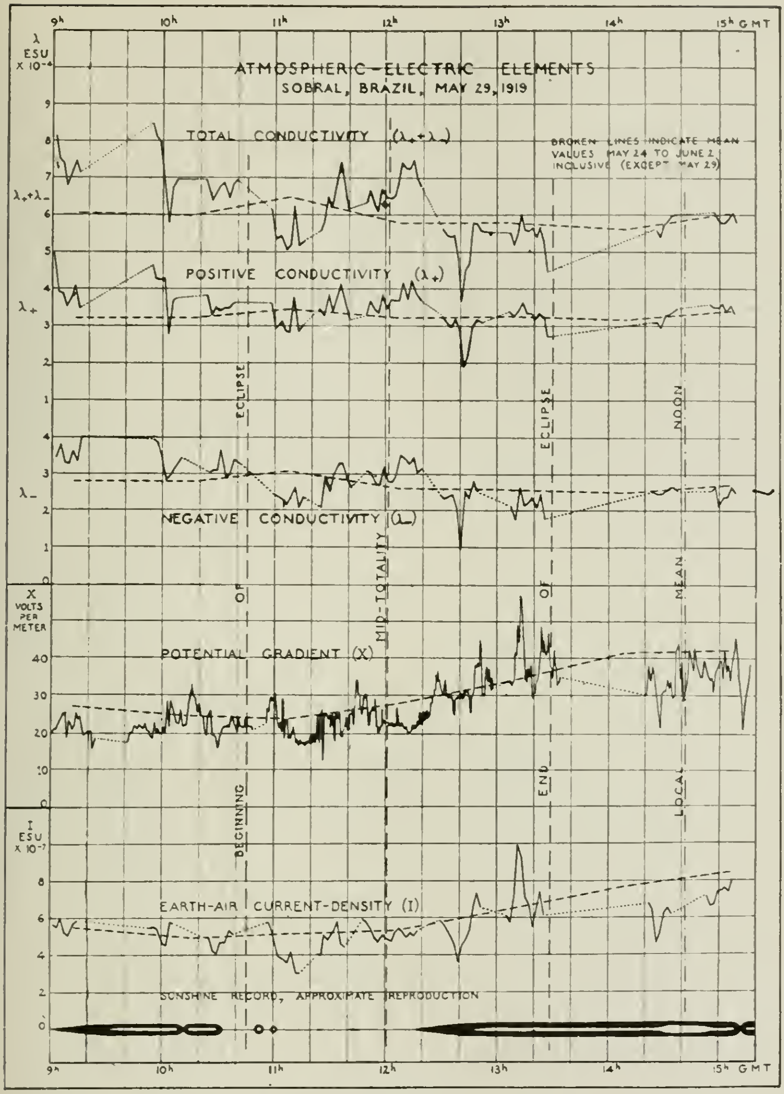

FIG. 4.—VARIATION OF ATMOSPHERIC-ELECTRIC ELEMENTS AT SOBRAL FOR SOLAR ECLIPSE MAY 29, 1919, AND MEAN CURVES.

20 percent., beginning just after totality and continuing for about 15 minutes.

(*d*) The air-earth current-density (product of simultaneous values of potential gradient and total conductivity) showed a greater constancy during the period in question than for any equal period throughout the forenoon of the day of the eclipse.

11. From the above it appears that the results for May 29, 1919, at the Sobral station are in general agreement with those obtained at Lakin, during the eclipse of June 8, 1918,[4] notwithstanding the great difference between the two stations as regards latitude, elevation, general topography, and distance from sea.

12. The Brazilian Government, through Dr. H. Morize, extended every kindness to the Department's party, providing substantial financial assistance for the building of apparatus shelters and for the entertainment of the observers, for all of which grateful acknowledgment is here made.

[4] *Terr. Mag.*, vol. 24, p. 96, June, 1919.

PRELIMINARY RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE FROM BUENOS AIRES, SOUTH AMERICA, TO ST. HELENA, FEBRUARY AND MARCH, 1920.[1]

By J. P. Ault, *Commanding the Carnegie.*

(*Observers*: J. P. Ault, H. F. Johnston, R. R. Mills, H. R. Grummann, and R. Pemberton.)

Date		Latitude	Long. East of Gr.	Carnegie Values			Chart Differences[2]					
							Decl'n and Incl'n			Hor. Int.[3]		
				Decl'n	Incl'n	Hor. Int.	Brit.	Ger.	U.S.	Brit.	Ger.	U.S.
1920		° ′	° ′	°	°	c.g.s.	°	°	°			
Feb.	24	37 04 S	305 01	2.2E	......	.....	0.2W	0.1W	0.3W	.....	.....	.....
	24	37 32 S	305 28	......	31.3S	.240	0.0	0.6S	0.9S	−11	−10	−4
	24	37 38 S	305 32	2.2E	......	.....	0.1E	0.2E	0.1W	.....	.....	.....
	25	38 58 S	307 04	1.2E	......	.....	0.1W	0.2W	0.1W	.....	.....	.....
	25	39 52 S	308 09	......	33.8S	.240	0.5N	1.0S	1.0S	−11	−10	−3
	25	40 02 S	308 19	0.6E	......	.....	0.1W	0.0	0.3W	.....	.....	.....
	26	40 27 S	309 31	0.1W	......	.....	0.0	0.1E	0.0	.....	.....	.....
	26	40 24 S	310 37	......	34.4S	.237	0.9N	1.0S	1.0S	−12	−11	−3
	26	40 24 S	310 59	1.0W	......	.....	0.3E	0.2E	0.3E	.....	.....	.....
	27	40 48 S	311 50	1.8W	......	.....	0.1E	0.2W	0.1E	.....	.....	.....
	27	41 54 S	312 05	......	36.1S	.238	1.3N	1.1S	1.0S	−11	−10	−3
	27	42 16 S	312 22	1.7W	......	.....	0.1E	0.2W	0.1E	.....	.....	.....
	28	43 28 S	313 18	2.0W	......	.....	0.1E	0.1W	0.0	.....	.....	.....
	28	44 17 S	313 51	......	38.7S	.239	1.6N	0.8S	1.0S	−11	−11	−3
	28	44 56 S	314 34	2.3W	......	.....	0.1E	0.0	0.0	.....	.....	.....
	29	45 54 S	316 56	4.3W	......	.....	0.4W	0.8W	0.6W	.....	.....	.....
	29	46 07 S	318 19	......	41.4S	.236	0.8N	0.7S	1.2S	−10	−10	−4
Mar.	1	45 47 S	323 30	......	42.2S	.231	0.8N	1.1S	1.1S	− 9	− 8	−2
	1	45 41 S	323 54	9.2W	......	.....	0.0	0.9W	0.3W	.....	.....	.....
	2	45 11 S	326 27	11.3W	......	.....	0.4W	0.7W	0.5W	.....	.....	.....
	2	45 06 S	327 49	......	43.3S	.224	0.5N	1.5S	1.4S	−10	− 9	−2
	2	45 10 S	328 06	12.6W	......	.....	0.5W	1.2W	0.8W	.....	.....	.....
	3	45 22 S	329 35	13.6W	......	.....	0.8W	1.3W	1.0W	.....	.....	.....
	3	45 34 S	330 43	......	44.7S	.222	0.4N	1.3S	1.3S	−10	− 8	−2
	3	45 42 S	331 19	14.4W	......	.....	0.7W	1.3W	0.7W	.....	.....	.....
	3	45 45 S	331 48	14.8W	......	.....	1.0W	1.6W	0.9W	.....	.....	.....
	4	45 59 S	333 35	15.6W	......	.....	0.7W	1.4W	0.6W	.....	.....	.....
	4	45 35 S	335 37	......	47.0S	.214	0.0	1.9S	1.4S	−12	−11	−4
	4	45 25 S	336 15	17.0W	......	.....	0.4W	0.8W	0.4W	.....	.....	.....

[1] For previous table, see *Terr. Mag.*, vol. 25, p. 9.

[2] Charts used for comparison: U. S. Hydrographic Office Charts Nos. 1700, 1701 and 2406 for 1920; British Admiralty Charts No. 3775 for 1917, 3598 and 3603 for 1907; Reichs-Marine-Amt Charts Tit. XIV, No. 2 for 1910; Tit. XIV, Nos. 2a and 2b for 1905. The chart differences are obtained by subtracting chart values, derived as explained in previous sentence, from the observed *Carnegie* values. The letter E signifies that the chart value for east declination is smaller, or the chart value for west declination larger, than the *Carnegie* value; W signifies the reverse. The letter N signifies that the derived chart value for northerly inclination is smaller, or for southerly inclination larger, than the *Carnegie* value; S signifies the reverse. The plus sign signifies that the derived chart value for horizontal intensity is smaller than the *Carnegie* value, the minus sign meaning, of course, the reverse. Secular corrections have been applied to declinations only.

[3] Expressed in units of third decimal C. G. S.

Date	Latitude	Long. East of Gr.	Carnegie Values			Chart Differences[2]					
						Decl'n and Incl'n			Hor. Int.[3]		
			Decl'n	Incl'n	Hor. Int.	Brit.	Ger.	U.S.	Brit.	Ger.	U.S.
1920	° ′	° ′	°	°	c.g.s.	°	°	°			
Mar. 5	44 36 S	338 47	18.9W	......	.....	0.6W	1.4W	0.7W	.....	.....	.....
5	43 59 S	340 27	......	48.2S	.206	0.1S	2.4S	1.2S	−14	−13	−6
5	43 44 S	341 04	21.6W	......	.....	1.8W	2.6W	2.0W	.....	.....	.....
6	42 46 S	343 25	22.2W	......	.....	1.1W	1.8W	1.2W	.....	.....	.....
6	42 08 S	345 00	......	49.4S	.201	0.2S	3.2S	0.4S	−14	−12	−4
7	40 52 S	348 08	25.6W	......	.....	1.8W	2.1W	1.8W	.....	.....	.....
7	40 42 S	348 33	......	50.3S	.196	0.1S	3.5S	0.0	−15	−14	−4
8	40 12 S	349 48	26.3W	......	.....	1.7W	2.0W	1.8W	.....	.....	.....
8	40 02 S	350 16	......	51.0S	.195	0.4S	3.9S	0.2S	−14	−14	−4
8	39 59 S	350 20	26.4W	......	.....	1.5W	1.7W	1.7W	.....	.....	.....
9	38 59 S	351 42	26.5W	......	.....	1.1W	1.0W	1.1W	.....	.....	.....
9	38 31 S	351 59	......	51.1S	.194	0.5S	4.1S	0.3S	−14	−14	−2
9	38 21 S	352 06	27.3W	......	.....	1.5W	1.3W	1.5W	.....	.....	.....
10	37 03 S	352 58	27.4W	......	.....	1.1W	0.7W	1.1W	.....	.....	.....
10	36 44 S	353 14	......	51.2S	.194	0.8S	4.6S	0.6S	−13	−13	−2
10	36 34 S	353 23	27.5W	......	.....	1.0W	0.7W	1.1W	.....	.....	.....
11	36 14 S	353 50	27.4W	......	.....	0.7W	0.4W	0.8W	.....	.....	.....
11	36 09 S	354 10	......	51.3S	.191	0.8S	4.6S	0.5S	−15	−15	−3
11	36 08 S	354 18	28.0W	......	.....	1.1W	0.7W	1.2W	.....	.....	.....
12	35 51 S	355 28	27.3W	......	.....	0.2W	0.3E	0.1W	.....	.....	.....
12	35 48 S	356 49	......	52.6S	.189	1.2S	4.8S	0.9S	−15	−16	−3
12	35 52 S	357 11	27.7W	......	.....	0.2W	0.2E	0.1E	.....	.....	.....
13	35 27 S	359 36	28.7W	......	.....	0.8W	0.3W	0.4W	.....	.....	.....
13	34 48 S	0 26	......	54.4S	.185	1.8S	5.0S	1.4S	−17	−17	−3
13	34 34 S	0 42	28.4W	......	.....	0.4W	0.1E	0.0	.....	.....	.....
14	33 20 S	1 45	28.6W	......	.....	0.6W	0.2W	0.3W	.....	.....	.....
14	32 46 S	2 13	......	54.5S	.181	2.0S	4.8S	1.6S	−20	−21	−7
14	32 38 S	2 19	29.1W	......	.....	1.2W	0.7W	0.9W	.....	.....	.....
15	32 22 S	2 27	28.6W	......	.....	0.7W	0.2W	0.4W	.....	.....	.....
15	31 50 S	2 52	28.6W	......	.....	0.8W	0.4W	0.5W	.....	.....	.....
16	31 15 S	3 16	28.3W	......	.....	0.6W	0.3W	0.2W	.....	.....	.....
16	30 47 S	3 36	......	54.1S	.188	2.5S	5.3S	1.7S	−14	−15	0
16	30 29 S	3 52	28.2W	......	.....	0.7W	0.3W	0.3W	.....	.....	.....
17	28 52 S	4 45	27.5W	......	.....	0.5W	0.1W	0.2W	.....	.....	.....
17	27 50 S	5 24	......	53.6S	.190	3.0S	5.7S	1.8S	−14	−15	0
17	27 32 S	5 37	27.0W	......	.....	0.5W	0.3W	0.2W	.....	.....	.....
18	25 41 S	7 04	26.6W	......	.....	0.8W	0.8W	0.5W	.....	.....	.....
18	24 52 S	7 19	......	52.7S	.194	3.2S	5.3S	1.9S	−14	−14	+1
18	24 30 S	7 21	24.9W	......	.....	0.4E	0.4E	0.8E	.....	.....	.....
19	22 37 S	7 32	24.1W	......	.....	0.5E	0.3E	0.6E	.....	.....	.....
19	21 59 S	7 38	......	50.3S	.201	2.7S	5.0S	1.5S	−13	−13	+1
19	21 47 S	7 40	24.4W	......	.....	0.3W	0.5W	0.1W	.....	.....	.....
20	20 00 S	7 49	23.2W	......	.....	0.0	0.1W	0.1E	.....	.....	.....
20	19 53 S	7 50	23.2W	......	.....	0.0	0.0	0.0	.....	.....	.....
20	19 24 S	7 53	......	48.6S	.210	2.6S	5.6S	2.0S	−12	−9	0
20	19 05 S	7 54	22.7W	......	.....	0.1E	0.1W	0.1E	.....	.....	.....
21	17 08 S	8 02	21.3W	......	.....	0.6E	0.3E	0.4E	.....	.....	.....
21	16 23 S	8 04	......	46.1S	.220	2.5S	5.5S	2.1S	−13	−10	−2
21	16 08 S	8 06	20.8W	......	.....	0.6E	0.3E	0.4E	.....	.....	.....
22	14 17 S	7 32	20.2W	......	.....	0.5E	0.2E	0.1E	.....	.....	.....
22	13 45 S	7 26	......	42.7S	.229	1.7S	5.6S	1.7S	−15	−14	−5

Date	Latitude	Long. East of Gr.	Carnegie Values			Chart Differences[2]					
						Decl'n and Incl'n			Hor. Int.[3]		
			Decl'n	Incl'n	Hor. Int.	Brit.	Ger.	U.S.	Brit.	Ger.	U.S.
1920	° ′	° ′	°	°	c.g.s.	°	°	°			
Mar. 22	13 39 S	7 24	20.0W	......	.....	0.5E	0.2W	0.0	.....	.....	.....
22	13 33 S	7 14	20.1W	......	.....	0.4E	0.3W	0.1W	.....	.....	.....
23	13 33 S	5 29	20.1W	......	.....	1.0E	0.3E	0.4E	.....	.....	.....
23	13 37 S	4 28	......	41.6S	.229	1.6S	7.3S	1.8S	−17	−14	−4
23	13 39 S	4 05	20.8W	......	.....	0.7E	0.1E	0.3E	.....	.....	.....
24	13 56 S	2 27	21.6W	......	.....	0.5E	0.2W	0.0	.....	.....	.....
24	14 01 S	1 53	......	40.3S	.231	1.0S	7.8S	1.5S	−16	−10	−3
24	14 01 S	1 40	22.0W	......	.....	0.4E	0.3W	0.0	.....	.....	.....
25	14 33 S	359 53	23.0W	......	.....	0.0	0.7W	0.3W	.....	.....	.....
25	14 47 S	359 09	......	39.4S	.228	1.7S	8.4S	0.9S	−18	−9	−4
25	14 54 S	358 49	23.3W	......	.....	0.0	0.5W	0.3W	.....	.....	.....
26	15 42 S	356 52	24.2W	......	.....	0.3W	0.7W	0.2W	.....	.....	.....
26	15 47 S	356 02	......	38.7S	.226	2.6S	9.9S	1.1S	−19	−9	+3
26	15 48 S	355 42	24.2W	......	.....	0.2W	0.5W	0.1E	.....	.....	.....

Notes on Trip from Buenos Aires to St. Helena.[1]

We left Buenos Aires under tow at $14^h\,06^m$, Saturday, February 21, 1920. At 16^h the tugboat was dismissed and the *Carnegie* proceeded down the Rio de la Plata, tacking against a head wind with only fore-and-aft sails set, and engine running. Good progress was made Saturday night and Sunday. By Sunday evening the wind and sea had increased to such a degree that it was necessary to anchor for the night. Early Monday morning we were en route again, tacking against a head wind as before, until noon when we reached the Recalada Light Ship and discharged the pilot. In order to make sure of clearing the coast with a good margin of safety, the engine was operated with the fore-and-aft sails until $18^h\,40^m$, steering southeast. We considered ourselves to be very fortunate in getting out of the river in such a short time considering the continuous head wind.

During the first week, the winds were moderate and variable. Several lightning and thunder storms were encountered. On February 28 a westerly gale sprang up and for 48 hours we ran ahead of it at a speed of about ten knots with no sails set except a goose-winged lower topsail. Owing to the confused seas, the waves washed over the ship from stem to stern at will. Water was sweeping over the quarter deck continuously.

The weather was getting cold and disagreeable as we went farther south, the air temperature reaching 6°.5 C., and the water temperature 7°.3 C., on March 2. A sharp lookout was kept for icebergs, as we were for ten days in a region where they have been encountered. On March 3 three large *icebergs* were seen,

[1] From Captain J. P. Ault's report dated March 27, 1920, St. Helena.

together with about 12 smaller ones scattered about over a radius of ten miles. On March 4 another large iceberg was seen, but none were seen thereafter.

Gough Island was sighted early Monday morning, March 8, and several very interesting hours were spent passing this lonely, uninhabited island of the South Atlantic. Several photographs of the island were taken. It seems to be the home of the wandering and sooty albatross, a number of which were caught and examined. According to our observations, the position given on British Admiralty chart No. 2228 for *Penguin Islet* is in error. The chart position is, latitude 40° 19′.2S, longitude 9° 56′.6W, whereas the *Carnegie* observations give, latitude 40° 15′.8S, longitude 9° 58′.W. The longitude difference may be due to chronometer error, but the latitude difference is due either to faulty plotting of Gough Island and Penguin Islet on the chart, or to error in the original latitude value.

As we turned northward toward St. Helena, the weather and temperature began to improve. The sea, however, continued very rough, due to storms south and west of us. During a calm on March 11 the engine was operated for a few hours. On March 15 the engine was operated for 12 hours during a calm, until we began to pick up a breeze from the southeast, which finally, on March 16, developed into the southeast trade wind. This wind remained with us until we reached St. Helena.

Declination observations were taken every day and on all but four days observations were made twice, and occasionally three times, daily. *Horizontal intensity and inclination observations* were omitted on one day, due to short run from previous station. The magnetic observations were made at 95 stations during the trip. The new galvanometer was used for a few days, until the sea became so rough that the coil could not be balanced.

The regular work has been carried out as usual, in spite of bad weather and disagreeable conditions. The testing of sea water for *ocean currents*, in accordance with the method of Dr. Mayor, has been taken up.

We have had good winds during the trip and have averaged 151 miles per day, the *Carnegie's* highest record so far for a passage of over 30 days duration.

DER JAEHRLICHE GANG DER ERDMAGNETISCHEN AKTIVITAET.

Von G. Angenheister.

Die Häufigkeit und Grösse erdmagnetischer Störungen, oder die erdmagnetische Aktivität, zeigt periodische Schwankungen. Die Periodenlängen dieser Schwankungen stimmen mehrfach so nahe mit periodischen Vorgängen in unserm Sonnensystem überein, dass man einen Zusammenhang vermuten muss. So spiegelt sich die elfjährige Periode der Sonnentätigkeit, die 26½tägige Periode der Sonnenrotation, die tägliche Axendrehung der Erde, in einer elfjährigen, 26½tägigen und in einer täglichen Periode der erdmagnetischen Aktivität wieder.

Der jährliche Umlauf der Erde um die Sonne erzeugt auf der Erde eine jährliche Schwankung der Sonnenstrahlung infolge der Neigung der Erdaxe gegen die Ekliptik. Für Orte ausserhalb der Wendekreise ist diese Schwankung eine ganzjährige mit Extremwerten im Juni und Dezember; Orte zwischen den Wendekreisen zeigen 2 Maxima zur Zeit des Zenitdurchgangs der Sonne. Ausser dieser durch die Neigung der Erdaxe gegen die Ekliptik erzeugten Schwankung, besteht noch eine ganzjährige Schwankung der Sonnenstrahlung infolge der Excentricität der Erdbahn. Ihr Maximum liegt zur Zeit des Perihels im Jahresanfang.

Man nimmt an, dass die erdmagnetischen Störungen von Tätigkeitscentren der Sonne ausgehen, die mit Flecken und Fackeln, vielleicht auch mit den Koronastrahlen in engem Zusammenhang stehen; vielleicht vermittelt durch eine elektrische Strahlung. Die Flecken und Fackeln beschränken sich im wesentlichen auf eine bestimmte Zone der Sonne (etwa von $+30°$ bis $-30°$ Sonnenbreite). Die Aequatorebene der Sonne bildet mit der Ebene der Ekliptik einen Winkel von etwa 7°. Die Knoten der beiden Ebenen passiert die Erde Anfang Juni und Dezember. Eine Strahlung, die nur von einer bestimmten Zone der Sonne ausgeht, muss wegen dieser Neigung von 7° im Lauf des Jahres auf der Erde mit veränderlicher Intensität wirken. Die Flecken, Fackeln und Coronastrahlen ändern nun mit der Zeit besonders in einem elfjährigen Cyklus ihre Stärke und Häufigkeit, wie auch ihre Lage auf der Sonnenoberfläche. Es wird darum schwierig sein, die verschiedenen Einflüsse der Lage der Ekliptik gegenüber der Rotationsaxe und der magnetischen Axe der Erde, sowie gegenüber der Rotationsaxe und magnetischen Axe der Sonne, im jährlichen

Gange der erdmagnetischen Aktivität wieder zu finden. Das Folgende ist nur ein erster orientierender Versuch.

Ein geeignetes Mass für das Studium der erdmagnetischen Aktivität ist die Energiedichte $\frac{f}{T} \cdot \int\limits_0^T v^2 dt$, wo v die magnetische Feldstärke und $f = \frac{1}{8}\pi$. Leider liegen nur sehr wenig Auswertungen magnetischer Registrierungen nach diesem Gesichtspunkt vor. Um statistisch das erdmagnetische Beobachtungsmaterial auf einen jährlichen Gang der Aktivität zu untersuchen, muss man sich einstweilen mit den erdmagnetischen Charakterzahlen begnügen. Diese sind ebenfalls ein Mass für die Energiedichte eines jeden Tages. Die Monatsmittel der Charakterzahlen (soweit sie mir hier zugängig waren 1910–1918) für 4 Stationen nördlicher Breite wurden zu einem mittleren jährlichen Gange vereinigt; für jede Station, ausgedrückt in Procent Abweichungen gegen ihr Jahresmittel für 1910–18. Ebenso für 4 Stationen südlicher Breite. Das Mittel der geographischen Breiten und der Inclination war für die nördlichen Stationen $\beta = + 25°$; $I = +3\gamma°$; für die südlichen $\beta = -18°$; $I = -35°$. Alle Stationen lagen zwischen $+31°$ und $-32°$ Breite. Der jährliche Gang zeigte zwei Maxima zur Zeit der Aequinoxien, und zwei Minima zur Zeit der Solstitien. Das Hauptmaximum lag jedoch im Mittel für die nördlichen Stationen im nördlichen Herbst; im Mittel für die südlichen Stationen dagegen im März; das Hauptminimum für die nördlichen Stationen im Juli, für die südlichen im Dezember. Die einzelnen Stationen zeigten jedoch starke Abweichungen gegen diese Regel.

Von längeren Beobachtungsreihen der Störungseinflüsse waren mir noch zugängig und wurden verglichen: Samoa, Charakterzahlen 1906–1919; Batavia, mittlerer Störungsbetrag in der Horizontal-Intensität 1883–99; Bombay, Unterschiede der Tagesmittel der Horizontal-Intensität aufeinanderfolgender Tage 1872–1905; Anzahl der Störungen für Honolulu, Porto Rico, Tuscon, Cheltenham und Sitka für 1902–16. Der Vergleich des jährlichen Ganges dieser Stationen zeigte stets die Maxima zu den Aequinoxien und die Minima zu den Solstitien; auch für die nördlichen Stationen das Hauptmaximum im September und für die südlichen im März; das Hauptminimum lag jedoch für die nördlichen sowohl wie für die südlichen Stationen im Dezember. Die Lage der Extreme im Jahre ist nicht konstant von Jahr zu Jahr, sondern scheint gesetzmässig zu wandern.

Bevor eine Erklärung dieses jährlichen Ganges erfolgen kann,

scheint es mir notwendig, weiteres Beobachtungsmaterial, auch von Stationen höher nördlicher und südlicher Breite, zu bearbeiten. Es wäre hierfür sehr vorteilhaft an Stelle der Charakterzahlen, die mittlere Aktivität eines jeden Monats zu berechnen.

Das Folgende kann jedoch wohl schon jetzt ausgesprochen werden: Ein Teil des jährlichen Ganges zeigt eine Abhängigkeit der geographischen Breite; das Hauptmaximum liegt auf der Nordhälfte der Erde um September, auf der Südhälfte um März.

In der Sonnentätigkeit sind ausser der 11jährigen noch andere Schwankungen enthalten. In den Sonnenflecken tritt besonders eine etwa 8monatliche hervor. Wenn hierdurch in der erdmagnetischen Aktivität ebenfalls eine solche 8monatliche Schwankung hervorgerufen wird, könnte diese bei Mittelbildung über mehrere Jahre vielleicht einen Einfluss gewinnen, der den von uns gesuchten jahreszeitlichen Gang fälschen würde. Es sind darum für die gleichen Zeiträume, für welche der mittlere jährliche Gang der Störungseinflüsse gebildet wurde, in gleicher Weise die Sonnenfleckenzahlen zu mittleren Monatsmitteln vereinigt und diese Zahlen der Tabelle und Kurventafel beigefügt. Daraus ist ersichtlich, dass der jährliche Gang der Aktivität kaum durch einen ähnlichen in den Sonnenflecken zu erklären ist.

Der Unterschied zwischen der Nord- und Südhälfte der Erde, die geographische Abhängigkeit der erdmagnetischen Aktivität, ist jedenfalls nicht durch Veränderungen in der Sonnentätigkeit zu erklären.

Jaehrlicher Gang der Erdmagnetischen Aktivitaet in ihrer Abhaengigkeit von der geographischen Breite.

I.—Oktober 1909 bis September 1913 und Juli 1914 bis Juni 1918.

Mittlere Monatsmittel der erdmagnetischen Charakterzahlen[1], in Abweichungen vom Jahresmittel in Procenten.

[Nordhälfte: Lukiapang, Bombay, Helwan, Honolulu. Mittlere Breite, +25°; mittlere Inclination, +37°. Südhälfte: Buitenzorg, Mauritius, Samoa, Pilar. Mittlere Breite, −18°; mittlere Inclination, −35°.]

Jan.	Febr.	März	April	Mai	Juni	Juli	Aug.	Sept.	Okt.	Nov.	Dez.
					Nord	hälfte.					
−2.3	+2.4	+8.5	−4.0	−4.0	−7.2	−11.8	+9.8	+5.7	+11.6	−3.7	−5.7
					Süd	hälfte.					
−7.9	+10.5	+12.5	+12.8	+6.7	−4.4	−9.5	+1.4	−3.1	−0.2	−6.6	−11.0
					Sonnen	*flecken.*					
34.4	36.2	36.8	35.8	41.4	41.8	46.7	45.5	41.9	47.4	42.4	42.0

II.—1906—1916.

Mittlere Zahl der Störungen pro Monat vom Charakter 2—4 in U. St. A.[2]
[Mittel aus Sitka, Cheltenham, Tuscon (Baldwin), Honolulu, Porto Rico.
Mittlere Breite, +33°; mittlere Inclination, +59°.]

0.73	0.78	1.20	0.96	1.15	0.66	0.62	1.29	1.36	0.98	0.67	0.40
			Erdmagnetische Charakterzahl Samoa,[1] *Breite, −14°; Inclination, −29°.*								
0.31	0.37	0.50	0.49	0.43	0.40	0.32	0.42	0.45	0.35	0.32	0.26
			Sonnenflecken.								
38.1	40.4	39.2	39.8	36.6	37.0	44.0	39.7	41.8	38.7	39.6	38.6

III.—1883—1899.

Mittlere Monatssumme der Differenz der Tagesmittel aufeinanderfolgender Tage, Horizontal-Intensität, in Gamma; Bombay[3]. *Breite, +19°; Inclination, −24°.*

Jan.	Febr.	März	April	Mai	Juni	Juli	Aug.	Sept.	Okt.	Nov.	Dez.
−21	+9	+10	+8	+8	−10	−13	+13	+37	−12	+9	−39
Mittlerer Störungsbetrag pro Tag; Horizontal-Intensität in Gamma; Batavia[4]. *Breite, −7°; Inclination, −31°.*											
−8.4	+2.8	+10.1	+5.4	+2.0	−4.4	−8.7	−4.7	+1.3	+4.2	+1.3	−0.8
			Sonnenflecken.								
38.6	41.8	37.1	43.8	42.8	45.9	46.1	44.1	42.3	38.9	34.1	38.9

[1] *Caractère Magnétique*, Commission internationale de Magnétisme terrestre, De Bilt.

[2] *Results of observations, made at the U. S. Coast and Geodetic Survey Magnetic Observatories.* 1901–16.

[3] *Bombay, Magnetic observations*, 1846–1905, part II.

[4] *Batavia, Magnetic Observations*, Vol. XXII, part II.

MAGNETIC STORM OF MARCH 22–23, 1920.

By D. L. Hazard, United States Coast and Geodetic Survey.

A comparison of the records of the magnetic observatories of the United States Coast and Geodetic Survey shows that this storm, like the one of August 11–12, 1919, had the same general characteristics at all of the observatories, but had little correspondence in detail beyond the abrupt beginning. Because of the rapid motion and wide range of the disturbance, portions of some of the records were lost or rendered unintelligible; at Cheltenham, the decrease in H (horizontal intensity) was so great as to carry the magnet of the Eschenhagen variometer beyond the point of stable equilibrium. At Sitka, the observer, at the time of changing paper, noticed that a severe storm was in progress and widened the slit of the lantern so as to strengthen the photographic record. *Greenwich mean civil time is used throughout this article.*

General Characteristics.—The storm began abruptly at about $9^h 10^m$, March 22, four hours of moderate activity being followed by about 6 hours of much greater activity. After a lull in the storm for three or four hours, the most severe portion began an hour or two before midnight and continued up to about 7^h on the 23d. The principal portion of the storm ended about 3 hours later, but there was considerable activity, particularly at Sitka, up to the end of the 25th.

Declination.—At Porto Rico, Cheltenham and Tucson, the initial motion was toward the east, but in the opposite direction at Sitka and Honolulu, although at Sitka there were small oscillations just before the point selected as the beginning. There was a sharp reversal of motion about a minute after the beginning. The first period of great activity, beginning soon after 13^h, was marked by an easterly motion of D (declination) at Sitka and Honolulu and a westerly motion at the other three stations, the amplitude being large at Sitka and Cheltenham. The declination continued below normal at Cheltenham and above normal at Sitka up to the end of this phase at about 19^h. During the second period of great activity, the wide oscillations of D extended about equally on both sides of the normal value except at Sitka, where the average was much below normal.

Values of Magnetic Elements for Salient Points of the Magnetic Storm of March 22-23, 1920.

Phase	Porto Rico		Cheltenham		Tucson		Sitka		Honolulu	
	Time	Value	Time	Value	Time	Value	Time	Value	Time	Value
				Declination						
	h m	° ′	h m	° ′	h m	° ′	h m	° ′	h m	° ′
Normal...	.. ..	−3 42.0	.. ..	−6 17.4	.. ..	+13 48.2	.. ..	+30 29.5	.. ..	+9 52.6
Beginning.	9 09	44.5	9 09	6 17.2	9 09	13 47.4	9 10	30 33.2	9 09	53.0
Reversal..	9 10	44.0	9 11	6 15.1	9 10	13 47.6	9 11	30 31.5	9 10	52.9
Minimum.	9 32	47.4	9 28	6 32.4	9 34	13 39.5	9 38	30 07.3	10 16	52.3
Maximum	13 23	33.5	12 58	5 50.8	13 11	13 55.9	13 30	32 44[2]	17 04	61.9
Minimum.	18 32	54.2	13 56	7 05.3	13 53	13 37.2	14 31	29 38.3	17 50	51.9
Maximum	.. ..	....	16 38	6 11.0	16 39	14 06.0	18 10	32 44[2]	18 03	61.7
Maximum	1 57	34.4	3 01	5 29.2	3 15	14 30.6	4 22	31 14.2	4 22	53.2
Minimum.	3 15	52.9	4 23	7 ·18[1]	1 21	13 26.2	4 29	27 31[3]	1 21	39.8
				Horizontal Intensity						
	h m	γ	h m	γ	h m	γ	h m	γ	h m	γ
Normal...	.. ..	27840	.. ..	19125	.. ..	26880	.. ..	15560	.. ..	28825
Beginning.	9 10	855	9 09	19135	9 09	903	9 10	15610	9 10	842
Reversal..	9 13	895	9 10	19211	9 12	983	9 15	15697	9 13	889
Maximum	9 58	896	9 10	19211	9 25	986	9 15	15697	9 29	912
Minimum.	18 44	570	14 01	18625[5]	16 41	597	.. ..	14744[7]	15 31	587
Maximum	22 17	680	23 36	19488[6]	22 11	824	3 44	16122	22 07	721
Minimum.	.. ..	535[4]	2 45	18629[5]	1 31	465	.. ..	14744[7]	4 42	400
				Vertical Intensity						
	h m	γ	h m	γ	h m	γ	h m	γ	h m	γ
Normal...	.. ..	34855	.. ..	55335	.. ..	45600	.. ..	55625	.. ..	23705
Beginning.	9 10	857	9 10	55321	9 10	620	9 12	55648	9 09	699
Reversal..	9 11	855	9 11	55323	9 13	623	.. ..	.....	9 12	721
Minimum.	13 57	737	15 09	55145	16 36	512	14 05	55049	10 17	690
Maximum	18 04	928	18 39	55537	13 20	623	.. ..	56039[9]	18 04	738
Minimum.	2 55	34844	3 07	54821	.. ..	.....	.. ..	54834[10]	23 39	679
Maximum	7 05	35000	23 30	55916[8]	3 15	819	0 38	55842	9 10	765

[1] Spot of light was off the magnetogram from $4^h\ 20^m$ to $4^h\ 26^m$; minimum less than the tabular value.

[2] Spot off from $13^h\ 25^m$ to $13^h\ 33^m$ and from $18^h\ 06^m$ to $18^h\ 14^m$; maximum greater than tabular value.

[3] Spot off just before this; value probably 1° less a minute or two earlier.

[4] Spot off from $23^h\ 40^m$ to $23^h\ 56^m$, from $0^h\ 41^m$ to $2^h\ 33^m$, from $2^h\ 34^m$ to $2^h\ 45^m$, from $2^h\ 55^m$ to $3^h\ 03^m$ and from $3^h\ 25^m$ to $3^h\ 50^m$. The minimum was no doubt much less than the tabular value.

[5] Spot off from $13^h\ 57^m$ to $14^h\ 05^m$; at $2^h.45^m$ the magnet was thrown out of equilibrium and the subsequent record was lost. It is estimated that a decrease of 1200γ would be required to do this.

[6] Maximum greater than this; magnet moving too rapidly to record.

[7] Spot off most of the time between $13^h\ 29^m$ and $15^h\ 47^m$ and again after $4^h\ 20^m$; minimum much less than tabular values.

[8] Spot off for a few minutes about $23^h\ 30^m$; maximum greater than the tabular value.

[9] Spot off from $15^h\ 35^m$ to $17^h\ 07^m$; maximum greater than tabular value.

[10] Spot off from $3^h\ 14^m$ to $3^h\ 27^m$, from $3^h\ 50^m$ to $4^h\ 05^m$, from $4^h\ 19^m$ to $4^h\ 34^m$ and from $9^h\ 14^m$ to $9^h\ 20^m$; minimum less than the tabular value.

Horizontal Intensity.—The initial motion was an abrupt increase followed within two or three minutes by a sharp reversal. At Sitka, the value fell from 15648γ at $10^h\ 08^m$ to 15088γ at $10^h\ 34^m$ and came back to 15675γ at $11^h\ 22^m$. This feature had no counterpart at the other observatories. The first period of great activity was marked by a sweeping decrease in H at all the observatories, from which there was a partial recovery during the lull, followed by a still further decrease during the second period of great activity. At Cheltenham, this decrease was so great as to throw the magnet of the Eschenhagen variometer out of equilibrium shortly before 3^h on the 23d and the instrument ceased to record. Rapid oscillations of wide range marked this period, the value at Sitka dropping from 16122γ at $3^h\ 44^m$ to 14744γ at $4^h\ 20^m$.

Vertical Intensity.—At Porto Rico there was a slight decrease at the beginning followed by an increase one minute later; at Cheltenham there was an increase followed by a decrease, but at the other observatories this initial "kick" could not be distinguished. At Cheltenham during the first period of great activity Z (vertical intensity) was below normal for about 3 hours and then above for 2 hours. During the second period it was high at first and then low. At Sitka Z was alternately low and high during the first period, above normal during the lull and low for the greater part of the second period. At Tucson Z was low during the first period and high during the second period.

Tables.—In the following tables are given the times of occurrence of salient points and the corresponding values for the five observatories. There is so little accordance after the beginning that only the extreme values are given for each of the two active periods. A plus sign signifies east declination, and a minus sign the reverse.

LETTERS TO EDITOR

THE AURORA BOREALIS OF MARCH 22–23, 1920, AS SEEN AT THE CHELTENHAM MAGNETIC OBSERVATORY.

Another *magnetic storm* of extraordinary magnitude was recorded on March 22–23, 1920, at the magnetic observatory of the United States Coast and Geodetic Survey, Cheltenham, Maryland, latitude 38° 44′.0 N., longitude 76° 50′.5 W. Its chief features are described in Mr. Hazard's article, pages 57–59. There was no recurrence of the storm 27 days later, April 19–20.

The *Aurora* was visible soon after sunset on March 22, 1920,

but was first noticed by the writer at 8^h 05^m 75th meridian time. At 8^h 10^m a display of rays developed, proceeding from a bright band low in the northern horizon some 45° in extent. The rays were visible from a point in the western horizon a few degrees (5°-10°) N. of the new moon (azimuth from S — 88°) to a few degrees in the eastern horizon east of Arcturus (azimuth = −76°.0), and apparently converged to a few degrees north of the planet Jupiter (azimuth 26.5 and altitude 68° .5). There was a conspicuously rosy colored ray in the east. The rays lasted for about 5 minutes. The boundary of the illuminated area was parabolic in form. The ray display was followed by a general diffused glow.

At 9^h 55^m the diffused glow was bounded by a lighter arc extending from near the planet Mars in the east to some 15° south of Jupiter toward the west. At 10^h 00^m the rays were developed on a grand scale, and seemed to emanate from an altitude of 20° in the north and 30° in the south. The rays converged to a point half way between the star Regulus and the planet Saturn (Alt. = 62°.5; az. = − 11°.0). This ray display lasted 15 minutes, and then flickering movements became conspicuous. There was a rosy glow in the west. At 10^h 40^m, nearly, the entire sky was illuminated. At 10^h 45^m rays were visible in the north. Rays were again strikingly conspicuous from 11^h 04^m to 11^h 15^m; they converged from all directions to a point near Saturn (alt. = 62°; az. = −12°.5), and were followed by flickering movements.

The observations ceased at midnight.

GEO. HARTNELL,
Observer-in-Charge.

Cheltenham, Maryland, April 27, 1920.

MAGNETIC STORM OF MARCH 22, 1920, AS RECORDED AT DEL EBRO OBSERVATORY.

At 9^h 10^m on March 22, 1920, there began a magnetic storm of considerable intensity, accompanied by the corresponding perturbations in the earth currents and other electrical elements registered at the Observatory.

The extreme values which give the maximum amplitude of the oscillation are for:

Declination (*D*): 11° 66′.5 at 16^h 40^m on March 22; 11° 11′.0 at 1^h 39^m on March 23; these values correspond to an oscillation of 23′.5W and 32′.0E, with respect to the mean value of the curve.

Horizontal Intensity (*H*): +50γ at 12^h 44^m on March 22; −280γ at 18^h 15^m on March 22.

Vertical Intensity (*Z*): −49γ at 13^h 50^m on March 22; +195γ at 17^h 17^m on March 22.

The center of gravity of an extensive area of solar perturbation crossed the central meridian about 17^h of the preceding day, March 21. The spot which precedes the group, crossed the meridian at approximately 19^h on March 20.

LUIS RODÉS, S. J.

MAGNETIC DISTURBANCES, EARTHQUAKE RECORDS, AND AURORA AT WATHEROO MAGNETIC OBSERVATORY, MARCH, 1920.

The following magnetic disturbances as observed during March, 1920, at the Observatory are here briefly reported upon, the times given being 120th east meridian standard time.

A *magnetic disturbance* was recorded on *March 4 and 5*, during which time there was serious interruption in the telegraphic service in Australia. The movements began suddenly and simultaneously in the three magnetic elements at $19^{h}\ 39^{m}$ P. M. (120th east meridian standard time) on March 4, but were not large until the early morning of March 5. During the night of March 5 conditions gradually returned to normal. The most important movement occurred between $5^{h}\ 00^{m}$ and 12^{h} on March 5, when the horizontal intensity was reduced by about 1 per cent of its value; the changes in declination and vertical intensity were not very large.

Another *magnetic disturbance* was recorded on the night of *March 14 to 15, 1920;* the variations were not of a very great amplitude, but some of them were very rapid. The commencement was at $20^{h}\ 52^{m}$ in all elements, and was very sudden. The total range was about 131γ in horizontal intensity, $14'.9$ in declination, and about 79γ in vertical intensity. Large movements had ceased by 3^{h} on March 15. Small, but sharp, movements recurred at intervals after the main disturbance had died down.

The *severe magnetic storm of March 22 to 23, 1920*, began at $17^{h}\ 09^{m}$ on March 22. There was a rapid decrease and subsequent rise in horizontal intensity between 7^{h} and 13^{h} on March 24, but otherwise there were no very large or rapid movements after 21^{h} on March 23. The most prominent feature was the great decrease in horizontal intensity, in which also the oscillations at times showed very great speed and amplitude. The horizontal-intensity trace went off of the recording sheet at $22^{h}\ 36^{m}$ on March 22, and remained off for the greater part of the time until 3^{h} on March 23; it was also off the sheet during $8^{h}\ 30^{m}$ until $14^{h}\ 40^{m}$, while during $14^{h}\ 40^{m}$ to $17^{h}\ 25^{m}$ it was oscillating on and off the paper, and then remained continuously on the paper and gradually settled down. The total range in horizontal intensity was certainly not less than 300γ, and was most likely considerably more as the magnet was several times driven against the stops. The ranges in declination and vertical intensity were $45'.5$ and about 292γ, respectively. The commencement was at $17^{h}\ 09^{m}$ on March 22 for the three magnetic elements.

An *aurora* was observed between 2^{h} and $2^{h}\ 30^{m}$ on March 23; it appeared as a pale, but distinct, pink glow above the clouds on the southern horizon, losing color and fading away gradually. According to the "West Australian", Perth, March 24, 1920, fine auroral displays were observed by the lighthouse-keeper at Cape Leeuwin from 9 P. M. to 3 A. M., on the night of March 22 to March

23, at other stations along the south coast as far as Adelaide, at Kalgoorlie, and faintly at Perth about 3 A. M., March 23.

The following *earthquakes* were recorded on the Watheroo magnetograms:

Date	Phase	D	H	Z
		h m	h m	h m
May 6, 1919	Beginning..................	3 51	3 56	4 05
	Maximum amplitude......	3 53	4 07	4 07
	Ending..................	4 05	4 24	4 15
Aug. 29, 1919	Beginning................	13 52	13 52	.. ..
	Ending..................	14 03	14 15	.. ..
Sept. 1, 1919	Beginning................	1 30	1 32	.. ..
	Ending..................	1 33	1 40	.. ..
Feb. 2, 1920	Beginning................	19 30	19 33	19 40
	Maximum amplitude......	19 33	19 49	19 52
	Ending..................	20 05	20 11	20 03
	(Waves of large amplitude began at $19^h\ 40^m$ and ended at $19^h\ 55^m$ on the horizontal-intensity trace.)			

Edward Kidson,
Observer-in-Charge.

Watheroo Magnetic Observatory,
West Australia.

SOLAR-CONSTANT VALUES AT CALAMA, CHILE, MARCH–APRIL, 1920

[The following values of the solar constant observed at the Smithsonian Institution station, Calama, Chile, as communicated by Dr. Abbot, are of special interest in connection with the severe magnetic storm of March 22–23, and the marked solar activity of that period.[1] It is very gratifying that Dr. Abbot has devised a method of observation and reduction which makes it possible to obtain a value of the solar constant within a few hours after the observations have been made and to receive the data at Washington as promptly as the mail service permits. The values from July, 1918, to January, 1920, inclusive, will be found in various issues of the *Monthly Weather Review*, January, 1919, to February, 1920. The values from January to March, 1920, Dr. Abbot states, "were all high—of the order of 1.96 to 2.00". It will be observed from the table that the lowest value (1.866) since January was observed on March 23.—Ed.]

Solar Constant Values, March 11–April 17, 1920.
[1.800 +tabular value.]

March..	11–17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Value...	.168	.154	.140	.131	.141	.127	.066	.105	....	.153	.166	.158	.169	.151	.157	.144	.160
April...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Value..	144	160	156	.162	.160	.125	.116	.127	.158	.161	.158	.155	.154	.157	.144	.135	.146

Astrophysical Observatory,
Smithsonian Institution.

C. G. Abbot.

[1] *Cf.* Note 17 on solar activity, March, 1920, page 75.

CONCERNING MAGNETOGRAM-SCALINGS AT THE BATAVIA-BUITENZORG MAGNETIC AND METEOROLOGICAL OBSERVATORY.

With great interest I have looked over the articles concerning the procedure with regard to magnetogram-scalings, published in the December, 1919, issue of *Terrestrial Magnetism and Atmospheric Electricity.*

Carefully examining the advantages and disadvantages of the three methods in question, I came to the conclusion that for Batavia should be adopted:

I. The publication of mean ordinates for 60-minute intervals, to begin with January 1st, 1920.
II. The adoption of standard time corresponding to 105° East of Greenwich.
III. The adoption of the local day.[1]
IV. The adoption of hour-intervals, 0^h–1^h, 1^h–2^h, etc.

Accordingly, starting December 31, 1919, the hour mark of the Adie magnetograph is given at the hour of standard time; for the Eschenhagen magnetograph this arrangement was already made when installing it at Buitenzorg many years ago.

Mean ordinates may be read very well with the glass magnetogram-scales, already in use here.

W. van Bemmelen.

[1] Since the longitude of the Batavia-Buitenzorg Observatory is $7^h\,07^m$ E. of G., Dr. van Bemmelen means by "local day" that corresponding to his standard time, 7^h.—Ed.

CONCERNING MAGNETOGRAM-SCALINGS AT LUKIAPANG MAGNETIC OBSERVATORY.

1. In January, 1917, we began scaling our magnetograms with mean scales very similar to those described by Mr. Fleming.[1] The 60-minute interval is counted from $0^h\,0^m$. But unfortunately, owing to the lack of personnel, it has been necessary to diminish the work. In consequence, the day is not divided into 24 hours, but into six intervals of 4 hours, the centers of which are 2^h, 6^h, 10^h, 14^h, 18^h, and 22^h.

2. The use of C. C. T. (China Coast time, not Central China) will be continued as since March, 1908.

3. The daily means will be given in C. C. T. and also in Greenwich time.

4. The values will be uncorrected for non-cyclic change, as in the past, since we do not wish to force our opinion and procedure upon the reader. This is likely to oblige us to have 8 columns instead of 6 for each month.

J. de Moidrey, S. J.

[1] *Terr. Mag.*, Dec., 1919, p. 154.

CONCERNING GLASS MAGNETOGRAM-SCALES.

In the December, 1919, number of *Terrestrial Magnetism and Atmospheric Electricity*, an article appears describing a glass magnetogram-scale used in the Department of Terrestrial Magnetism. I do not know how the glass slides are prepared but in case any one has not seen the "graticules" prepared by the Rheinberg process, may I suggest the possibility of having them done in that way rather than by direct ruling on the glass.

The process is described in the *Transactions of the Optical Society*, May, 1919. It consists of a photographic transference of the diagram or pattern required, on to the surface of the glass and a subsequent deposit of platinum which is burnt into the surface of the glass.

I have used, for drawing purposes, a glass scale made in this way which consists of three inches, divided into two-hundredths, and I find that with the use of an ordinary watchmaker's eyeglass, it is possible to make measurements with an accuracy of about two-thousandths.

In making such a scale, it is originally drawn in a larger size and reduced photographically. There is a risk of distortion of course if the lens is not a good one, but I could detect no measureable error in the three-inch scale that I have.

The platinum deposit appears to be quite permanently embedded in the glass. I believe Messrs. Penrose and Co., 109 Farringdon Road, London E. C., are commercial agents for Mr. Rheinberg.

THOS. Y. BAKER, Instructor-Commander R. N.

ADMIRALTY COMPASS OBSERVATORY,
Slough, Bucks, February 25, 1920.

EIN MANGEL DER ERDMAGNETISCHEN JAHRBUECHER.

Von Adolf Schmidt in Potsdam.

Um dem Verständnis und der Erklärung einer verwickelten Erscheinung, wie es der Ablauf der erdmagnetischen Vorgänge ist, näher zu kommen, hat man vor allem ihre Zerlegung in einfachere, wenn möglich selbständige, aus verschiedenen Ursachen entspringende Teile zu erstreben. Freilich setzt eine vollkommen zutreffende derartige Zerlegung schon die Kenntnis der doch erst das Endziel der Forschung bildenden Ursachen der Erscheinung voraus, so dass man sich auf diesem Wege anscheinend im Kreise bewegt. Aber bei zweckmässigem Vorgehen kann dieser doch zur Spirale werden, die sich dem Ziele mehr und mehr nähert. Das ist am ehesten möglich, wenn sich die Teilerscheinungen in ihrem zeitlichen oder räumlichen Charakter deutlich von einander abheben, so dass man sie zunächst wenigstens nach formalen Gesichtspunkten trennen kann.

Solches ist bei den erdmagnetischen Erscheinungen der Fall. Von einem gewöhnlich weit überwiegenden, nur sehr langsam veränderlichen Mittelwerte jedes Elements sondern sich schnelle um ihn pendelnde Schwankungen ab, die teils einen periodischen Charakter tragen, teils ganz unregelmässig zu verlaufen scheinen. Die genauere Betrachtung lässt dann noch bei dem Mittelwerte eine weitere Scheidung in einen sehr glatt und regelmässig verlaufenden Hauptteil und in Schwankungen von verschiedener mittlerer Dauer erkennen, die sich mit abnehmender Stärke im Gange der Tages-, der Monats- und selbst noch der Jahresmittel abzeichnen. Bei den letzten machen sie sich noch recht deutlich als Unregelmässigkeiten des säkularen Ganges bemerkbar.

Die kürzesten, nach Tagen messenden Einzelheiten dieses Ganges der Mittelwerte sind im wesentlichen mit der von *van Bemmelen* als Nachstörung bezeichneten und eingehend studierten Erscheinung identisch, besser gesagt mit der etwa als Grundstörung zu bezeichnenden Hauptwelle der einzelnen Störung, deren allmähliches Ausklingen die Nachstörung darstellt. Ich habe sie gelegentlich auch Broun'sche Schwankung genannt, weil J. A. Broun sie zuerst bemerkt und eingehend untersucht hat.[1] Sie zeigt,

[1] *Edinburgh, Roy. Soc. Transactions*, **22**, 1861, S. 511.—Vgl. *Archiv des Erdmagnetismus*, Heft 3, S. 22.

wie Fig. 1 erkennen lässt, überall einen ausserordentlich ähnlichen, nur an Stärke mit dem Orte wechselnden Verlauf, so dass sie im wesentlichen nur in einer Intensitätsschwankung eines seiner Gestaltung nach wenig veränderlichen, verhältnismässig einfach gebauten Feldes besteht. Die Erscheinung lässt sich danach in erster Annäherung in der Form $f(\theta).\phi(t)$ darstellen, worin $f(\theta)$ eine Funktion des Ortes, und zwar, wie sich zeigt, im wesentlichen eine solche des Winkelabstandes von der magnetischen Achse der Erde, und $\phi(t)$ eine Funktion der Zeit ist. Der Wert von $\phi(t)$ steigt, wie Fig. 1 erkennen lässt, bei jeder Störung zuerst rasch an, um dann mit abnehmender Geschwindigkeit allmählich wieder zu sinken. Das ist besonders bei der dargestellten horizontalen Komponente der Fall.

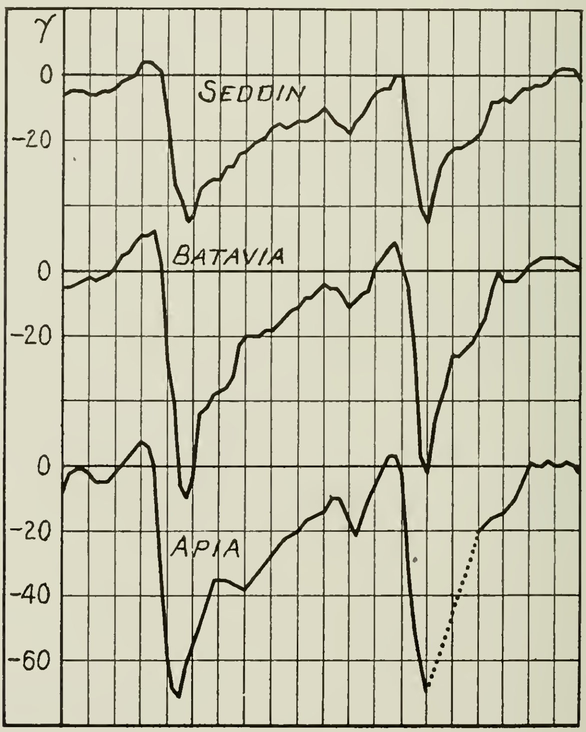

FIG. 1.

Es handelt sich danach bei der Broun'schen Schwankung um eine sehr charakteristische und verhältnismässig einfache Erscheinung, die von allen anderen erdmagnetischen Vorgängen deutlich unterschieden, wenn auch zunächst nur näherungsweise davon abzutrennen ist. Ihre Ursache kann kaum in etwas anderem gesucht werden, als in Strömen elektrischer Partikeln, die die magnetische Erdachse umkreisen (wenn negativ, von West nach Ost, wenn positiv, von Ost nach West) und die bei jeder Störung neu gespeist werden, während sie unter der Wirkung ihrer eigenen inneren Kräfte durch allmähliche Zerstreuung wiederum verschwinden.

Die Abhängigkeit der Broun'schen Schwankung von den Störungen, denen sie ihre Entwicklung verdankt, macht es ohne weiteres begreiflich, dass sie mit dem wechselnden Steigen und Fallen der Sonnenaktivität gleichfalls an Stärke zu- and abnimmt.[2] Die auffallende, schon oft hervorgehobene und erst kürzlich hier von L. A. Bauer[3] näher untersuchte Beziehung zwischen den Schwankungen des säkularen Ganges und der wechselnden Sonnenfleckenhäufigkeit hängt damit unzweifelhaft auf das engste zusammen. Ob jene Schwankungen ausschliesslich den nicht ausgeglichenen Rest der von Tag zu Tag ablaufenden Mittelwertsänderungen bilden oder ob in ihnen noch Wirkungen anderer Art zur Geltung kommen, mag dabei zunächst dahingestellt bleiben. Dass die erste Annahme wenigstens genähert zutrifft, kann mit grosser Wahrscheinlichkeit daraus geschlossen werden, dass die Unregelmässigkeiten der Säkularvariation im Gegensatz zu dieser selbst auf der ganzen Erde einander sehr ähnlich sind und anscheinend in der gleichen Form $f(\theta).\phi(t)$ wie die Broun'sche Schwankung dargestellt werden können[4]. In geringerem Masse scheint dies von der jahreszeitlichen Variation zu gelten, so dass diese vielleicht zu einem merklichen Teile auf Ursachen anderer Art beruht.[5]

Bei der grossen theoretischen und (für die Redaktion von Beobachtungen auf eine feste Epoche) auch praktischen Wichtigkeit der betrachteten Erscheinung ist es einigermassen zu verwundern,

[2] Eine vergleichende graphische Uebersicht der Schwankung des Mittelwerts der Nordkomponente X während des ersten Halbjahrs 1911 mit den Internationalen Charakterzahlen und mit der von BIDLINGMAIER für Wilhelmshaven abgeleiteten magnetischen Aktivität findet man in den *Ergebnissen der Magnetischen Beobachtungen in Potsdam und Seddin* im Jahre 1912, S. 30.

[3] Relation between the secular variation of the Earth's magnetism and solar activity. *Terr. Magn. and Atm. El.*, XXIII, S. 1, 61.

[4] Magnetische Karten von Norddeutschland für 1909. *Veröffentl. d. Kgl. Pr. Met. Inst.* Nr. 217. *Abhandlungen* Bd. III, Nr. 4. S. 24.

[5] Ergebnisse der Magnetischen Beobachtungen in Potsdam und Seddin in den Jahren 1900-1910. *Veröffentl. d. Kgl. Pr. Met. Inst.*, Nr. 289. *Abhandlungen* Bd. V. Nr. 3, S. 34, 35.

dass ihr bisher nur geringe Aufmerksamkeit geschenkt worden ist. Das spricht sich u. a. darin aus und erklärt sich andererseits hinwiederum daraus, dass die Jahrbücher der magnetischen Observatorien den Gang der Mittelwerte nur mangelhaft berücksichtigen. Sie beschränken sich im allgemeinen auf die Angabe der Tagesmittel der Elemente nach Ortszeit. Dieses für ein genaueres Studium der Erscheinung zu dürftige Material wird obendrein in seinem Werte noch dadurch beeinträchtigt, dass sich die Angaben der verschiedenen Stationen, weil jede den Tag eben nach Ortszeit begrenzt, nicht auf denselben Augenblick beziehen, also gar keinem einheitlichen Phänomen angehören.

Welchen Einfluss diese Umstände ausüben, zeigen die fünf in Fig. 2 vereinigten Darstellungen des Ganges des 24stündigen Mittels von H in Seddin an den 20 Tagen von 1908, November 4–November 23. Die Mitte des Intervalls, aus dem das jedesmalige Mittel berechnet ist, fällt bei I auf 0^h (Mitternacht), bei II, III, IV auf 6^h, 12^h, 18^h nach Weltzeit. Die Linie III enthält also (wenn man von dem Zeitunterschied zwischen Seddin and Greenwich absieht) die gewöhnlichen Tagesmittel. In V (das mit der obersten Kurve in Fig. 1 identisch ist) sind sämtliche Werte eingetragen, so dass also hier der gesuchte Gang in 6stündigen Intervallen angegeben vorliegt. Ein noch engeres Intervall zu wählen, erscheint als überflüssig; es wird dadurch kaum noch etwas geändert. Dagegen geben die vier ersten Linien, under einander und mit der fünften verglichen, offenbar nicht nur ein recht schematisches, sondern auch vielfach, besonders an den Stellen der Extreme, ein stark entstelltes Bild. Dieser letzte Umstand ist beim Vergleich des Verlaufs an verschiedenen Observatorien von wesentlicher Bedeutung. Wäre beispielweise an vier Stationen under 0°, 90°, 180°, 270° geographischer Länge der tatsächliche Gang genau derselbe als der durch V dargestellte, so würde er sich bei Verwertung der nach Ortszeit (von Mitternacht bis Mitternacht) gebildeten Tagesmittel doch merklich verschieden ergeben, denn an der ersten Station würde man die Linie III, an der zweiten IV, an der dritten und vierten I und II erhalten.

Hiernach rechtfertigt sich der Wunsch, dass in den magnetischen Jahrbüchern simultane, in hinreichend kurzen, am zweckmässigsten 6stündigen Zwischenräumen fortschreitende Mittelwerte der Elemente D, H, Z, oder X, Y, Z veröffentlicht werden möchten, sei es in zahlenmässiger oder in graphischer Form, am besten natürlich das eine und das andere. Es ist dies bisher nur für

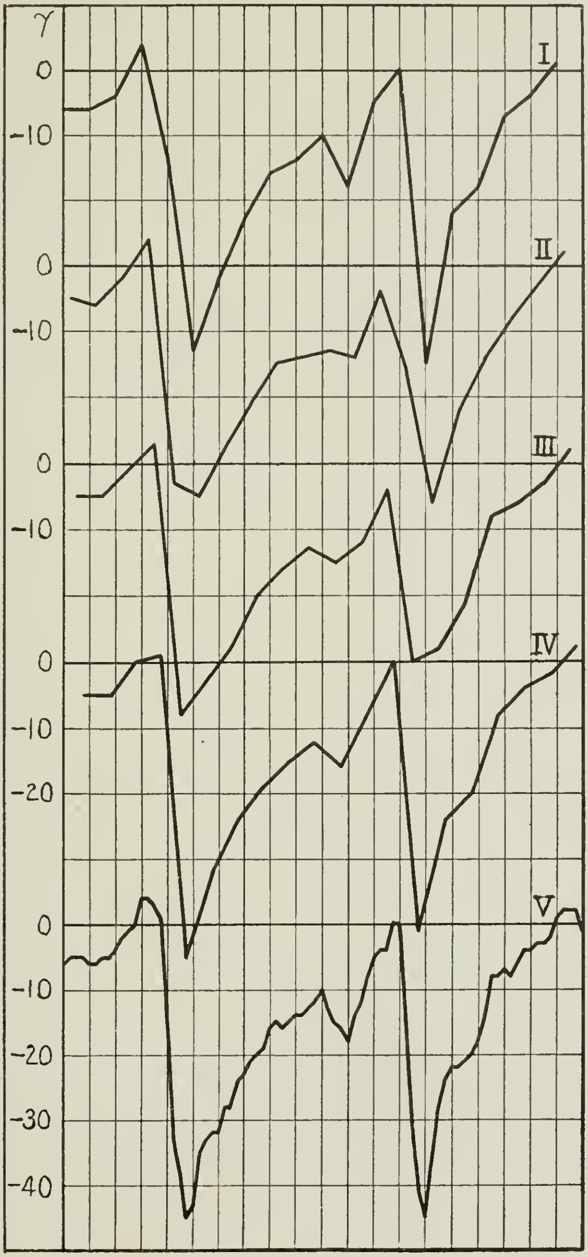

Fig. 2.

Potsdam-Seddin (seit 1905), Batavia (seit 1908) und Apia (für 1905 bis 1908) geschehen. Erfreulicherweise wird auch Sodankulä, einer mündlichen Mitteilung von Herrn Keränen zufolge, dem von diesen drei Observatorien gegebenen Beispiele folgen. Es braucht wohl kaum gesagt zu werden, dass die Berechnung der von 6 zu 6 Stunden fortschreitenden Mittelwerte nur geringe Mehrarbeit verursacht; man verfährt offenbar am zweckmässigsten so, dass man zunächst die Summen von je 6 Stundenwerten (von 0^h bis 6^h u. s. w.) bildet.

Die Darstellung geschieht wohl am besten so, dass man nicht die absoluten Werte, sondern ihre Abweichungen von einem provisorisch als normal angenommenen gleichförmigen Verlaufe angibt, von dem der Uebergang zu einem andern, etwa später gewählten leicht möglich ist. In den Seddiner Kurven, von denen Fig. 3 die für 1917 gültigen als Beispiel bietet, ist für den Anfang und das Ende des Jahres der Mittelwert der 12 symmetrisch dazu gelegenen, einschliessenden Monate als normaler Betrag angenommen; zwischen den zwei so erhaltenen Werten ist dann das Jahr hindurch linear interpoliert.

Observatorien, die sich zu einer solchen ausführlichen Darstellung noch nicht entschliessen können, sollten wenigstens ausser den eigentlichen, bisher stets gebrachten Tagesmitteln auch die Mittel derjenigen 24 Stundenwerte berechnen und veröffentlichen, die sich dem Greenwicher bürgerlichen Tag am besten anpassen. Geschähe dies allgemein, so würden die so erhaltenen simultanen Mittelwerte einen schon recht brauchbaren Ersatz der erstrebten ausführlicheren Uebersicht des Verlaufs auf der ganzen Erde geben.

An die einleitenden Bemerkungen anknüpfend, sei zum Schlusse noch betont, dass natürlich die 24stündigen Mittelwerte nur eine annähernde Darstellung des eigentlich gesuchten Vorgangs liefern. Weder sind in ihnen die Störungen völlig ausgeglichen, noch ist der ja nicht streng periodische tägliche Gang vollkommen eliminiert In dieser Hinsicht einen weiteren Fortschritt zu erzielen, muss aber zunächst besonderen Untersuchungen überlassen bleiben. Die Aufgabe der Jahrbücher kann immer nur die sein, die umfangreichen unmittelbaren Beobachtungsergebnisse so weit zu bearbeiten, wie es nach dem augenblicklichen Stande der Wissenschaft möglich und zur Förderung der weiteren Forschung erwünscht ist. In dem Masse aber, in dem diese fortschreitet, wird sich auch der Kreis jener Aufgaben, deren regelmässige Erledigung von den Observatorien und ihren Veröffentlichungen zu fordern ist, mehr und mehr ausdehnen.

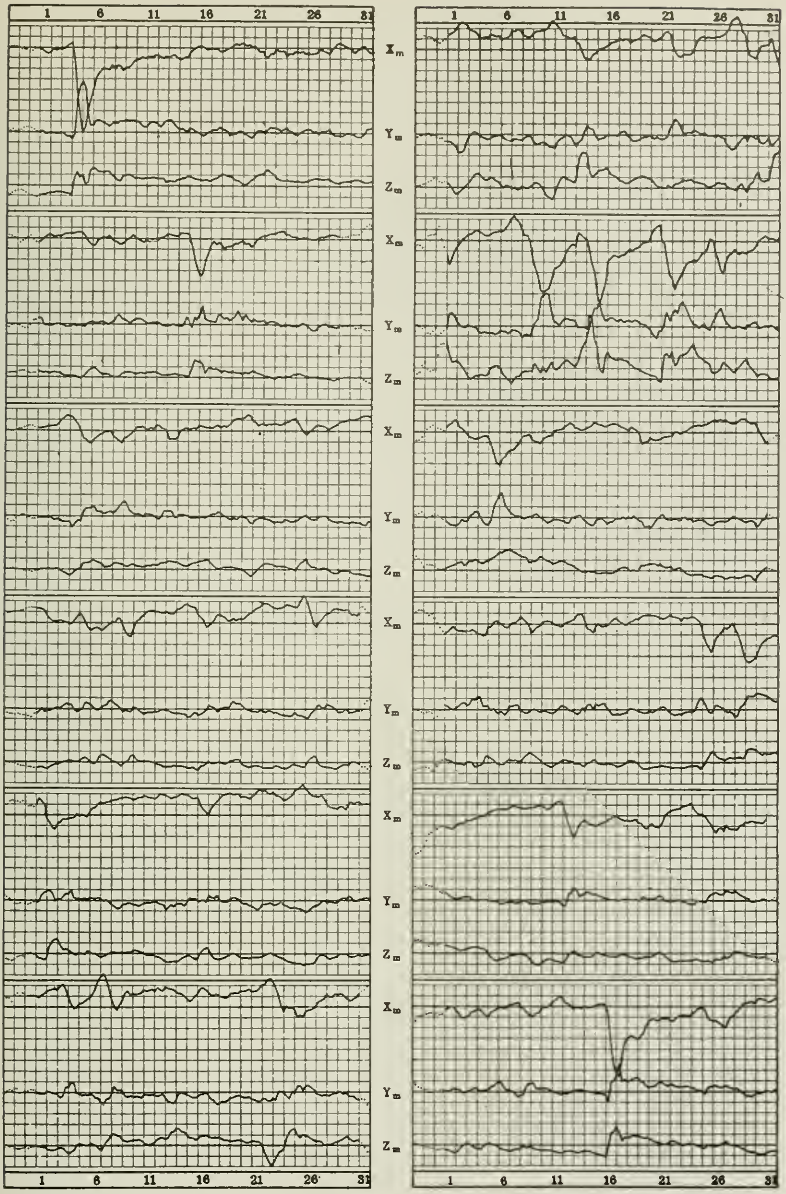

FIG. 3.

ABSTRACTS

SCHERING, HELMUTH: *On the dependence of the distance between the equivalent poles of a permanent bar magnet on its magnetic moment.*[1]

The author refers to earlier experimental work by Mascart, Benedicks, Lamb, Kohlrausch and Hallock, and Boergen, of whom the first three used ballistic methods, the others magnetometric methods. He bases the present work on the method of Boergen, which, considerably improved, he considers particularly suitable.

In this method a small magnet A is suspended by a fine fibre with its axis in the magnetic meridian, and the magnet under investigation, B, is so placed that its axis is normal to the meridian and that it does not deflect the magnet A from the meridian, the axes of both magnets being horizontal and in the same horizontal plane. Departures from ideal conditions make it necessary, in the practice of the method, to place the magnet B in each of the four quadrants and to work with the axis directed both east and west in each quadrant.

It is shown that, without knowledge of the Earth's horizontal intensity or the moment of the magnet B, the pole-distance can be determined, according to Lamont's deflection equation for two magnets, from the length of the magnet B and the distances of the centers of both magnets from the intersection of their axes in the eight positions of the magnet B.

The apparatus was mounted with great care as to stability, and great precision of measurement is claimed.

Four magnets were investigated, each 0.5 cm. in diameter and 10 cm. long. The results, tabulated and plotted in curves between pole-distance and moment, and also pole-distance and intensity of the field used to produce the magnetization, appear to show that, beginning with the smallest moments for which measurements are given, the pole-distance at first increases rapidly and then more slowly, the slope quickly becoming almost zero. The author believes that he has established a slight diminution of pole-distance just after the rapid increase for small moments, followed by a slow increase, then a more rapid increase, disappearing as saturation is reached.

Boergen had previously found the slight diminution, but had investigated only one magnet and had not investigated the earlier and later parts of the curves. The results are similar to those of Benedicks and of Lamb, except that these investigators found a minimum pole-distance for weaker fields than those for which the author gives data and except for what the author considers an apparent discrepancy between his results and those of Benedicks in regard to the relation between pole-distance and permeability. This, however, he attributes to the fact that his experiments were made on steel while those of Benedicks were made on soft iron.

S. J. BARNETT.

DEPARTMENT OF TERRESTRIAL MAGNETISM.

[1] Dissertation, Universität zu Göttingen, 1919.

Hazard, D. L.: *Alaska Magnetic Tables and Charts for 1920.*[1]

The present publication is warranted by the accumulation of a large number of additional observations in the 10 years which have intervened since the appearance of the "Distribution of the Magnetic Declination in Alaska and adjacent Regions for 1910". The dip and horizontal intensity results, though not so abundant as those for declination, are still sufficient to determine fairly well the distribution of those two elements for all but the extreme northwestern part of the territory. The secular changes were determined from 28 stations, one-half of which are on the coast, the remainder being inland in Alaska or the adjacent Yukon Territory in Canada. In addition to the tables of repeat observations and reduction corrections, tables are given containing the available results of magnetic observations in Alaska and on the adjacent sea since 1870, all reduced to a common epoch, Jan. 1, 1920.

In the construction of the charts (scale, 1:7,000,000), the graphical method was employed. Several regions of unusual disturbance are noted. On the isogonic chart the lines of equal annual change in declination are shown but their determination can be but approximate at best on account of the limited number of repeat stations. For the other two elements (horizontal intensity and inclination) no attempt to draw the lines of equal annual change has been made, though it is noted that the inclination seems to be decreasing over the greater part of Alaska at the rate of 1′ or 2′ a year, and that the annual change in horizontal intensity is small.

H. W. Fisk.

Department of Terrestrial Magnetism.

[1] Washington, D. C., U. S. Dept. Comm., Coast Geod. Surv., Spec. Pub. No. 63, 1920 (31 with 3 charts). 23 cm.

NOTES

9. Principal Magnetic Storms at Cheltenham Magnetic Observatory, January to March, 1920.[1]

Greenwich Mean Time		Range		
Beginning	Ending	Declination	Hor'l Int.	Vert'l Int.
h m	h	′	γ	γ
Mar. 4, 11 35	Mar. 5, 9	74.5	270	526
Mar. 22, 9 09	Mar. 23, 10	109.2[1]	869[1]	1095[1]

[1]Ranges were larger but actually measured ranges are given.

10. Regarding Loanda Meteorological and Magnetic Observatory.[2] The Observatory is under the temporary charge of the Commandant of the Port, whom I saw yesterday afternoon. A new director, Senhor João Capello, has been appointed from Lisbon, who is to arrive next month with self-recording apparatus and new instruments.

[1] Communicated by E. Lester Jones, Superintendent U. S. Coast and Geodetic Survey; Geo. Hartnell, Observer in Charge; Lat. 38° 44.0′ N.; long. 76° 50.5′W., or 5h 07.4m West of Greenwich.

[2] Information supplied by Observer F. Brown, of the Department of Terrestrial Magnetism, in letter.

11. Magnetic Observatory at La Quiaca, Argentina.[1] The magnetic work has not yet been started at La Quiaca. The non-magnetic, wooden absolute and variation observatories are built but piers are not yet placed. Inability to secure absolute instruments has handicapped the progress of the work.

12. Magnetic Observatory at Toolangi, Australia. In the February, 1920, number of *Monthly Notices of the Royal Astronomical Society*, Dr. *J. M. Baldwin*, Government Astronomer of the Melbourne Observatory, reports on magnetic observations and reductions during the year 1919 as follows: "The new magnetic variation observatory at Toolangi was completed during the year, and the Eschenhagen instruments have been in operation there since the beginning of August. The daily attendance is performed by one of the residents of the locality, but visits are made each month for determination of scale values, etc. The functioning of the instruments has been satisfactory except for the vertical force instrument, which is liable to be overturned by mechanical shocks. The records with the Adie instruments at Melbourne were discontinued at the end of the year. No curves have been measured, but the classification of the curves has been forwarded quarterly to De Bilt. The absolute value of the earth's magnetic field was determined 22 times during the year."

13. Hongkong Magnetic Observatory. Director *T. F. Claxton*, in his report of the Royal Observatory, Hongkong, for the year 1919, after giving the mean values of the magnetic elements observed at that Observatory for the years 1918 and 1919, makes the following statement: "The old magnetic hut is about to be demolished and the site used for quarters for the European assistants. In order to avoid a break in the series of magnetic observations, comparisons for horizontal force and declination are being made with Elliott No. 55 in the old hut and Elliott No. 83 in the new hut (constructed last year); also for dip with Dover No. 71 in the old and new huts."

14. Physikaliche Berichte. We note that this new periodical is being issued from the press of Friedr. Vieweg und Sohn in Braunschweig. It is being published under the joint auspices of the Deutsche Physikaliche Gesellschaft and the Deutsche Gesellschaft für technische Physik and edited by Karl Scheel. It is to serve as the continuation of the *Fortschritte der Physik, Halbmonatliches Literaturverzeichnis* and the *Beiblätter zu den Annalen der Physik.* The first (1920) volume is to appear semi-monthly in 24 parts and the price is fixed in Germany at 80 marks.

15. Norwegian Geophysical Commission. "Den Geofysiske Kommission" represents a union of Norwegian institutions and explorers in the domain of hydrography, terrestrial magnetism and Aurora-Borealis investigations. The Norwegian State has granted means, so that the Commission can issue a series of publications "Geofysiske Publikationer" containing scientific geophysical essays in English, French, and German. Each essay will appear in one separate number and will be sent out as soon as it has been printed.

16. Venice International Meteorological Meeting 1920. During the coming October, at a date to be announced later, the *International Meteorological Meeting*, convened by the Italian Meteorological Society, will take place at Venice. Information regarding the various subdivisions will be given out shortly; in the meanwhile, those intending to participate are requested to communicate their

intention to the *Comitato Ordinatore, Osservatorio Seminario Patriacale, Venice, Italy.* The fee of adhesion is ten lire.

17. Solar Activity, March, 1920. In view of the various magnetic disturbances during march, as printed elsewhere, the following extract from the *Observatory* for April, 1920 (page 166), will be of interest: "Early in the month activity was slight. On March 3, two small spots were present, and a fairly large prominence at the east limb. On March 8, 9, there were three spots in the northern belt, while the northern hemisphere was inactive. On March 19 a new large group was seen near the east limb, showing remarkably complicated structure. The whole group extended over about one-fifth of the solar diameter, and observations on March 22, 23, 25, indicated rapid variations. There were three main spot-centers, occupying the preceding and following ends and the centre of the group respectively, while the whole of the intermediate area was occupied by a great number of small umbrae. Spectroheliograms on the above days, taken in calcium light, show the whole group as a connected mass, but the accompanying flocculi were not specially prominent. It is interesting to note that this spot-group was at very low solar latitude, almost equatorial, and that it passed central meridian about March 22, and on the evening of that day a brilliant auroral display was reported. If the group lasts it will pass the western limb about March 29, and might be expected round again at the eastern limb about April 12."

18. Magnetic Observations during Amundsen's Arctic Expedition, 1918–1919. On March 29, 1920, the Department of Terrestrial Magnetism received the following message from Capt. *Roald Amundsen*, through the United States Naval Communication Service:

"Send two pair of total intensity needles for dip circle 205 to Norwegian Consul, Nome, Alaska, to be there not later than August 1, 1920. Sending all our work from last winter at Cape Tscherskin to your address via Dickson Island. Magnetic work proceeding nicely." Judging from messages received by others, "Tscherskin" is presumably Cape Chelyuskin where he appears to have been until about August, 1919. (*Cf.* Note 4, p. 45, March, 1919, issue of *T. M.*) The desired magnetic needles have been forwarded to Nome for Capt. Amundsen.

19. Personalia. We regret to record the following deaths: Capt. *E. W. Creak*, C. B., F. R. S., formerly Superintendent of Compasses, Hydrographic Department, Admiralty, on April 3, 1920, at eighty-four years of age (for portrait and biographical sketch, see December, 1904, issue of this Journal); Prof. *Julius Elster*, at Wolfenbüttel, on April 8, 1920, after a short illness; Vice-Admiral *Campos Rodrigues*, Director of the Lisbon Observatory; Prof. *J. A. McClelland*, F. R. S.; Dr. *J. G. Bartholomew*, on April 13, 1920.

Professor *R. A. Sampson*, Astronomer Royal for Scotland, was the Halley lecturer for 1920 at the University of Oxford. Mr. *E. W. Maunder* has retired from active service at the Royal Observatory, Greenwich. Mr. *J. A. Fleming*, Chief of the Magnetic Survey Division of the Department of Terrestrial Magnetism, returned to Washington in April, from a satisfactory inspection trip to the *Carnegie*, while at Buenos Aires last January, and to the Huancayo Magnetic Observatory being built in Peru by the Department, under the charge of Dr. *H. M. W. Edmonds.*

[3] Extract from letter of Mr. J. A. Fleming, Buenos Aires, Argentina, March 4, 1920.

20. *International Research Council.* We have received from the secretary, Sir Arthur Schuster, *Reports of the Proceedings*[1] of the Constitutive Assembly held at Brussels, July 18–28, 1919. The statutes of the Council and of the various Unions, established under the auspices of the Council, are printed both in French and English. The chief matters of interest to readers of this Journal have already been given in the September, 1919, issue (pp. 105–112).

21. *International Geodetic and Geophysical Union.* Besides the National Committee of Great Britain and that of Japan in process of organization, the following National Committees of the Union have been organized:

France. On January 24, 1920, the National Committee met at the Sorbonne and elected as officers: *M. Lacroix*, president, and *General Ferrié*, secretary. The six sections of which the Committee is composed, chose their presidents and secretaries as follows: Geodesy, *General Bourgeois*, president; and *Lieutenant-colonel Perrier*, secretary; Seismology, *M. Bigourdan*, president, and *M. Rothé*, secretary; Meteorology, *M. Violle*, president, and *Lieutenant de vaisseau Rouch*, secretary; Terrestrial Magnestism and Atmospheric Electricity, *M. Daniel Berthelot*, president, and *M. Mathias*, secretary; Oceanography, *M. Renaud*, and *M. Berget*, secretary; Volcanology, *M. Lacroix*, president and *M. Gentil*, secretary.

Canada. The National Committee was organized in April as follows: Surveyor General, *ex-officio*; Director of the Meteorological Service, *ex-officio*; Superintendent of the Geodetic Survey, *ex-officio*; Superintendent of the Tidal and Current Surveys, *ex-officio*; Chief Hydrographer of the Naval Service Department, *ex-officio*; and four representatives of the Royal Society of Canada, to be chosen in May.

United States of America. The American Geophysical Union, which is to serve both as the National Committee of the International Union and the Geophysics Committee of the National Research Council, was permanently organized in 1920 under the auspices of the National Research Council. At its annual meeting in Washington on April 23, there were chosen as its officers: *William Bowie* (U. S. Coast and Geodetic Survey), chairman; *Louis A. Bauer* (Department of Terrestrial Magnetism), vice-chairman; *Harry O. Wood* (National Research Council), secretary. The Executive Committee consists of the chairman, secretary and chairmen of the sections (Geodesy, *William Bowie*; Seismology, *Harry F. Reid*; Meteorology, *Charles F. Marvin*; Terrestrial Magnetism and Electricity, *Louis A. Bauer*; Physical Oceanography, *George W. Littlehales;* Volcanology, *H. S. Washington*). An additional section (Geophysical-Chemistry) was also established, whose officers will be chosen later. The complete organization, personnel and proposed work of the sections of particular interest to readers of the Journal will be given later.

Dr. W. van Bemmelen Lectures in the United States. On his way to Holland, *Dr. W. van Bemmelen* gave a series of illustrated lectures at various universities and societies in the United States on the volcanoes of Java. While at Washington in June, he also gave a talk at the Department of Terrestrial Magnetism on the work of the Royal Magnetical and Meteorological Observatory at Batavia. He will stay for a year on furlough in Holland.

[1] Harrison and Sons, London, April, 1920; price, 10s 6d., 8°, 286 pp.

RECENT PUBLICATIONS

A. Terrestrial and Cosmical Magnetism.

Agincourt and Meanook Observatories. Magnetic disturbances. November-December, 1919. Toronto, J. R. Astr. Soc. Can., v. 14, No. 2, Mar., 1920 (81–82).

Agincourt and Meanook Observatories. Magnetic observations (1919). Toronto, J. R. Astr. Soc. Can., v. 14, No. 3, April, 1920 (120–121).

Antipolo Observatory. Hourly results of the observations made at the Magnetic Observatory of Antipolo, near Manila, P. I., during the calendar year 1913. (Part IV of the annual report of the Weather Bureau for the year 1913.) Manila, Bureau of Printing, 1919, 47 pp. 29 cm.

Baldwin, J. M. Report on the work at the Melbourne Observatory during 1919. London, Mon. Not. R. Astr. Soc., v. 80, No. 4, Feb., 1920 (401–403). [Mean values of the magnetic elements for 1917, 1918 and 1919 are given.]

Baschen, O. Die Ermittelung der Nordrichtung durch den Kompass. Wetter, Berlin, v. 36, 1919 (108–110).

Bauer, L. A. Annual report of the Director of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, 1919. Repr. Washington, D. C., Carnegie Inst., Year Book No. 18 (277–316 with 1 pl.). 25 cm. [Contains plate showing the magnetic work of the Department of Terrestrial Magnetism, 1905–1919 (October).]

Bauer, L. A. Résumé of observations concerning the solar eclipse of May 29, 1919, and the Einstein effect. Science, New York, N. Y., N. S., v. 51, No. 1317, Mar. 26, 1920 (301–311). Abstr. Nature, London, v. 105, No. 2636, May 6, 1920 (311–312).

Chapman, S. Terrestrial magnetic variations and their connection with solar emissions which are absorbed in the earth's outer atmosphere. Cambridge, Trans. Phil. Soc., v. 22, No. 16, 1919 (341–359).

Chree, C. Magnetic storm of March 4–5 [1920]. Nature, London, v. 105, No. 2628, Mar. 11, 1920 (56).

Chree, C., and A. L. Cortie. The magnetic storm of March 22–23 [1920] and associated phenomena. Nature, London, v. 105, No. 2631, Apr. 1, 1920 (136–138).

Cortie, A. L. Sun-spot areas and terrestrial magnetic horizontal ranges and disturbances, 1919. Observatory, London, v. 43, No. 550, March, 1920 (121).

Dufour, Ch. Valeurs des éléments magnétiques à l'Observatoire du Val-Joyeux au 1er janvier 1920. Paris, C.-R. Acad. sci., T. 170, No. 4, Jan. 26, 1920 (245).

Eblé, L. Observations magnétiques en France pendant les années 1912 et 1913. Ann. bur. cent. météor., Paris, 1, 1912 [1918] (1–35 avec 3 pls.).

Hazard, D. L. Terrestrial magnetism. Art. in American Year Book, 1919. New York, D. Appleton & Co., 1920 (622–623).

Hazard, D. L. Alaska magnetic tables and magnetic charts for 1920. Washington, D. C., Dept. Comm., U. S. Coast Geod. Surv., Spec. Pub. No. 63, 1920 (31 with 3 maps in pocket). 23 cm.

Hongkong, Royal Observatory. Monthly meteorological bulletin, December, 1919. Containing detailed results of observations made at the Royal Observatory, Hongkong, and the daily weather reports from various stations in the Far East. Prepared under the Direction of T. F. Claxton, Director. Hongkong, Noronha and Co., Govt. Printers, 1920 (ca. 64 with 2 pls.). 33 cm. [Contains "Results of Magnetic Observations, 1919."]

Hongkong, Royal Observatory. Report of the Director of the Royal Observatory, Hongkong, for the year 1919. (T. F. Claxton, Director.) Hongkong, Noronha & Co., Govt. Printers, 1920, 17 pp. 24 cm.

Mauritius. Results of magnetical meteorological and seismological observations for the months May to October, 1919. New series (monthly) v. 5, parts 5 to 10. Royal Alfred Observatory, Mauritius (A. Walter, Director, and M. Koenig, Officer-in-Charge). Mauritius, Govt. Press, 1919, 32 cm.

Meteorological Office Observatories—Geophysical Journal. Daily values—solar radiation, meteorology, atmospheric electricity, terrestrial magnetism, and seismology. Units based on the C. G. S. system. Eighth year, Nos. 5–12, May-Dec., 1918; Ninth year, Nos. 1–3, Jan.-Mar., 1919. London, Meteorological Office, 1919–1920. 31 cm.

Meteorological Office. Hourly values from autographic records: 1916. Comprising hourly readings of terrestrial magnetism at Eskdalemuir Observatory and summaries of the results obtained in terrestrial magnetism, meteorology, and atmospheric electricity chiefly by means of self-recording instruments at the observatories of the Meteorological Office. (British Meteorological and Magnetic Year Book, 1916. Part IV.) London, Meteorological Office, 1919 (98 with 6 pls.). 31 cm.

Mitchell, A. C. The magnetic storm of March 22–23 and associated phenomena. Nature, London, v. 105, No. 2632, April 8, 1920 (170).

Nippoldt, A., und K. Kaehler. Magnetische und luftelektrische Arbeiten der Carnegie-Institution von 1916 bis 1918. Naturwissenschaften, Berlin, 8. Jahrg., Heft. 10, 5. März 1920 (187–192 mit 1 Karte).

Pola. Rapporto annuale delle osservazioni meteorologische, magnetische e sismiche. Nuova serie, v. xxiii (47. a annata dell'intera serie.) Osservazioni dell' anno 1918 pubblicate dalla Sezione "Geofisica". Pola, Ufficio Idrografico, 1920 (xviii + 142). 32 cm. P.

Roussilhe, H. Note au sujet des cartes publiées par la mission hydrographique Congo-Oubangui-Sanga (1910–1913). Ann. Hydrogr., Paris, 3e série, T. 3, 1918 (77–103). [Gives results of magnetic observations at 7 stations.]

Schmidt, Ad. Ergebnisse der erdmagnetischen Beobachtungen in Potsdam im Jahre 1918. Met. Zs., Braunschweig, Heft 5–6, Mai–Juni, 1919 (158–159).

Walker, G. W. The magnetic re-survey of the British Isles for the epoch January 1, 1915; and Appendix: A report on magnetic disturbances in Northampton and Leicestershire and their relations to the geological structure, by A. H. Cox (drawn up at the request of the Iron-ore Committee of the Conjoint Board of Scientific Societies). London, Phil. Trans. R. Soc., A, v. 219, No. 570, 1919 (viii + 135 with 8 figs. and 9 maps and charts in pocket).

B. *Cosmical Electricity and Radioactivity.*

Baldet, F. Sur la variation diurne du potentiel atmosphérique à l'Observatoire d'Alger. Paris, C.-R. Acad. sci., T. 170, No. 13, 29 mars 1920 (818–820).

Boss, L. J. The aurora of March 22, 1920. Pop. Astr., Northfield, Minn., v. 28, No. 4, Apr., 1920 (248–249).

Girousse. Sur la distribution dans le sol des courants émis des lignes de traction électrique. Paris. C.-R. Acad. sci., T. 170, No. 14, 6 avril 1920 (841–843).

Girousse. Sur le calcul du courant lancé dans le sol par les rails des tramways électriques. Paris, C.-R. Acad. sci., T. 169, No. 19, 10 novembre 1919 (846–849). Abstr. 186, Sci. Abstr., London, Section B, v. 23, Pt. 2, No. 266, Feb. 28, 1920 (98–99).

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Stebbins, J. The aurora of March 22, 1920. Science, New York, N. Y., N. S., v. 51, No. 1324, May 14, 1920 (485–486).

Störmer, C. Sur l'absorption des rayons corpusculaires pénétrant dans l'atmosphère terrestre en suivant des trajectoires non rectilignes. Paris, C.-R. Acad. sci., T. 170, No. 12, 22 mars 1920 (742–744).

Störmer, C. Situation, dans l'espace, de quelques aurores boréales. Observations faites à Bygdo, près de Christiania, pendant l'automne 1919. Paris, Bul. soc. astr. France, 34e année, avril 1920 (160–163 avec 1 pl.).

Vegard, L., and O. Krogness. The position in space of the Aurora Borealis from observations made at the Haldde-Observatory 1913–1914. (Geofysiske Publikationer, v. 1, No. 1, utgit av den Geofysiske Kommission.) Kristiania, A. W. Brøggers Boktrykkeri A/S, 1920 ([x] + 172 with 29 pls. and 37 figs.). 29 cm.

C. *Miscellaneous.*

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Chant, C. A. The observer's handbook for 1920. Twelfth year of publication. Toronto, R. Astr. Soc. Can., 1920, 64 pp. 20 cm.

Crommelin, A. C. D. The eclipse expedition to Sobral (May 29, 1919). Observatory, London, v. 42, No. 544, Oct., 1919 (368–371).

Eclipse, May 29, 1919. Joint eclipse meeting of the Royal Society and the Royal Astronomical Society 1919, November 6. Observatory, London, v. 42, No. 545, Nov., 1919 (389–398).

Eclipse, May 29, 1919. Eclipse photographs. Observatory, London, v. 42, No. 545, Nov., 1919 (405 with 2 pls.). [The plates show views of the eclipse taken by the British expeditions at Sobral, Brazil, and Principe.]

Hellmann, G. Beiträge zur Geschichte der Meteorologie. Zweiter Band (Nr. 6–10). Berlin, Veröff. met. Inst., No. 296, 1917 (vi + 340 mit 3 Tafeln u. 1 Tabelle). 29½ cm.

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Klotz, O. Observatories in Canada. Toronto, J. R. Astr. Soc. Can., v. 13, No. 7, Sept., 1919 (322–332). [Pertains to astronomical and meteorological observatories.]

Lyons, H. G. Lt.-Col. B. F. E. Keeling. (Obituary.) Nature, London, v. 104, No. 2612, Nov. 20, 1919 (317–318).

Mayor, A. G. Detecting ocean currents by observing their hydrogen-ion concentration. Repr.: Philadelphia, Pa., Proc. Amer. Phil. Soc., v. 58, No. 2, 1919 (150–160).

Nipher, F. E. Graphical representation of functions of the *N*th degree. Repr.: Philadelphia, Pa., Proc. Amer. Phil. Soc., v. 58, 1919 (236–240).

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Russell, H. N. On the navigation of airplanes. Repr. Pub. Astron. Soc. Pacific, No. 181, June, 1919, 21 pp.

Stebbins, J. The International Astronomical Union. Pop. Astron., Northfield, Minn., v. 27, No. 9, Nov., 1919 (601–612).

United States Naval Observatory. Annual report of the Naval Observatory for the fiscal year 1919. (Appendix No. 2 to the annual report of the Chief of the Bureau of Navigation, 1919.) Washington, D. C., Govt. Print. Off., 1919, 23 pp. 23 cm. [Contains report of the Compass Office, Division of Nautical Instruments and Time Service; Aeronautical Instruments; Nautical Instrument Repair Shop, pp. 5–12.]

Wendt, G. L. Jacques Danne (obituary). Science, New York, N. Y., N S., v. 50, No. 1293, Oct. 10, 1919 (340–341).

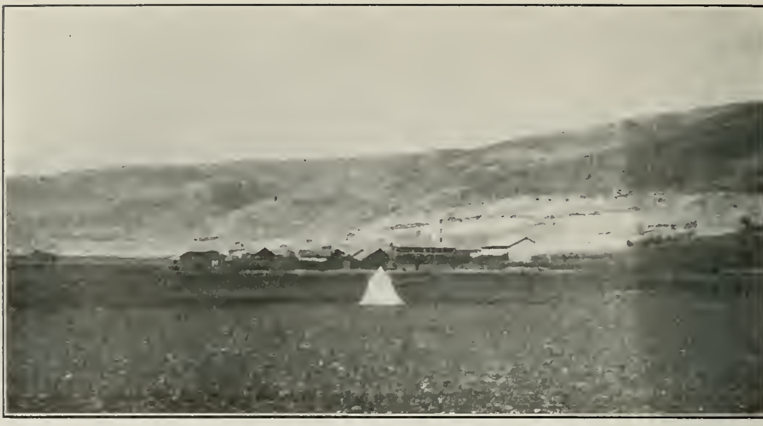

FIG. 1.—HUAYAO, PERU.

FIG. 2.—SUBRAL, BRAZIL.

FIG. 3.—CAPE PALMAS, LIBERIA.

CHIEF STATIONS OF DEPARTMENT OF TERRESTRIAL MAGNETISM,
SOLAR ECLIPSE MAY 29, 1919.

Terrestrial Magnetism
and
Atmospheric Electricity

VOLUME XXV SEPTEMBER, 1920 NUMBER 3

RESULTS AND ANALYSIS OF MAGNETIC OBSERVATIONS DURING THE SOLAR ECLIPSE OF MAY 29, 1919.—SUMMARY I.

BY LOUIS A. BAUER.

INTRODUCTION.

1. The total solar eclipse of June 8, 1918, was the recurrence of the one of May 28, 1900, for which the writer planned and directed the first systematic observations arranged to detect a possible appreciable magnetic effect connected directly with the eclipse of the Sun. For both eclipses, 1900 and 1918, the results were affirmative, as well as instructive.[1] The total eclipse of the Sun on May 29, 1919, was the recurrence of the one of May 18, 1901, the belt of totality of which began in the Indian Ocean, about where the totality-belt for May 29, 1919, ended, and continued across Sumatra to New Guinea. The international magnetic observations for May 18, 1901, made in accordance with the writer's appeal and directions, again led to positive results and gave additional information.[2]

2. The results for May 28, 1900, and May 18, 1901, showed the magnitude and character of the magnetic effect which might reasonably be associated with a withdrawal from a portion of the Earth of solar radiation during an eclipse of the Sun. Essentially the effect detected was of the same character as the nocturnal portion of the solar-diurnal variation, and the lunar-diurnal variation, the magnitude of the effects being about the same. When the characteristics of the eclipse magnetic effect had become known and its progression with the passage of the shadow cone had been shown, some magnetic observations made during the solar eclipses

[1] *Terr. Mag.*, vol. 5, 1900, p. 165; vol. 24, 1919, p. 16.

[2] *Terr. Mag.*, vol. 7, 1902, pp. 188-192.

of December 22, 1870, in Italy, and December 12, 1871, in Java, were investigated by the writer.[3] Negative conclusions had been drawn by the observers, as they looked for an unreasonably large magnetic effect which, of course, they found absent. However, the actual eclipse magnetic effect (in declination, 1′ or 2′) was distinctly revealed, as was shown by a comparison of the declination curve for the solar eclipse of December 12, 1871. at Batavia, with that for the solar eclipse of May 28, 1900, at the writer's station, Rocky Mount, North Carolina.[4]

3. Dr. van Bemmelen had two observing stations in Sumatra during the total solar eclipse of May 18, 1901, and also tested the possibility of a magnetic effect during the *annular* solar eclipse of March 17, 1904. His results together with those previously announced by the writer, led him to make an examination of available data from magnetic observatories, mainly in the Orient, situated near the belts for the total solar eclipses of August 18, 1868, December 12, 1871, April 6, 1875, May 17, 1882, August 19, 1887, August 9, 1896, May 18, 1901, and for the annular solar eclipses of April 6, 1894, and March 17, 1904. He reached positive conclusions and summarized the results obtained in an instructive table.[5]

4. The writer next called for co-operative magnetic and allied observations during the solar eclipse of August 30, 1905, and himself made observations at Missanabie, Canada, where unfortunately during the critical stages a severe magnetic storm prevailed. However, Dr. C. Nordmann made continuous registrations of the variations of magnetic declination and horizontal intensity from August 14 to September 20, 1905, at Philippville, Algiers, inside the belt of totality. He reached positive conclusions as to an eclipse magnetic effect and gained additional information of theoretical interest.[6] Dr. A. Nippoldt also made magnetic observations for the solar eclipse of August 30, 1905, his station being at Burgos, Spain. He likewise, in general, reached positive conclusions and made valuable contributions.[7]

5. Dr. Charles Chree has briefly discussed the results of the magnetic observations made at Kew Observatory in connection

[3] *Terr. Mag.*, vol. 7, 1902, pp. 184-188.

[4] *Terr. Mag.*, vol. 7, 1902, opposite p. 186.

[5] Contribution to the knowledge of the influence of solar eclipses on terrestrial magnetism *Natuurkundig Tijdschrift voor Ned.-Indie*, Deel LXIV, afl. 3-4, 1905, p. 29.

[6] *Terr. Mag.*, vol. 12, 1907, pp. 23-26; *Annales du Bureau des Longitudes*, tome 8, 1911, pp. D. 1-D. 60.

[7] *Physik. Zs.*, Jahrg. 7, 1906, pp. 242-248.

with the solar eclipse of April 17, 1912.[8] He considers it to be a natural inference "that the exclusion or diminution of direct solar radiation in any portion of the Earth's atmosphere will tend to reduce the electrical currents resident there, and thus correspondingly diminish their contribution to the magnetic diurnal variation". Having, however, before him only the data for Kew, he is unable to decide whether some of the effects observed were to be associated directly with the eclipse, or not.

6. Dr. V. Carlheim-Gyllensköld arranged an instructive and elaborate plan of observations at various stations for the solar eclipse of August 21, 1914, but, unfortunately, his results have not yet become known. However, international observations made according to the writer's appeal and plans were discussed by L. A. Bauer and H. W. Fisk and published in 1916.[9] It was found that "there was good reason for believing that an observable magnetic effect occurred during the time of the solar eclipse of August 21, 1914, at stations within the region of visibility, the effect being larger for stations near the belt of totality than for those further away". Complete discussion was deferred as it had been hoped that before long Carlheim-Gyllensköld's data would become available.

7. Professor Luigi Palazzo also made magnetic and allied observations in connection with the solar eclipse of August 21, 1914, his station, Theodosia, Crimea, being in the totality-belt.[10] Palazzo concludes[11] "that a small magnetic effect referable to the eclipse has manifested itself, especially in the declination curve. The principal disturbance occurred almost 6 minutes before totality and its range may be estimated about $0'.85$ (the north end of the declination needle being deflected towards east by a disturbing force of 5.7γ)."

8. In the foregoing paragraphs no attempt has been made to give an exhaustive account of the literature, which has grown to respectable size since 1900. Only those publications have been cited which contain discussions or an analysis of the data. Owing

[8] *Q. J. R. Meteor. Soc.*, vol. 39, 1913, pp. 231-236.

[9] *Terr. Mag.*, vol. 21, 1916, pp. 57-86.

[10] *Mem. Soc. spettroscop. ital.*, vol. 6, 1917, pp. 1-49, 5 pls. (Besides giving an account of his own observations and comparisons of effects at various stations, the author makes reference also to previous observations.)

[11] *Terr. Mag.*, vol. 23, 1918, p. 30.

to the minuteness of the possible effects, they cannot always be definitely connected with a solar eclipse, if but the data at a single station are available. Many observers have been stimulated to participate in eclipse magnetic observations and thus a large mass of data has now been accumulated.

9. Reference to the data and results for the solar eclipse of June 8, 1918, has already been made in paragraph 1. The evidences of a direct relation between the magnetic effects as shown at various stations, and the solar eclipse were so numerous as to leave scarcely any further doubt that an appreciable variation in the Earth's magnetic field occurs during a solar eclipse. The results at the writer's mountain station, Corona, Colorado, altitude 11,800 feet, were found of special interest.

10. The solar eclipse of May 29, 1919, offered an excellent opportunity to observe, or test, the "solar-eclipse magnetic variation" near the magnetic equator, as well as in both magnetic hemispheres. The circumstances of the eclipse and the chief observing stations are shown on the map, Fig. 1. Besides data from 7 observing stations of the Department of Terrestrial Magnetism, co-operative observations were once more obtained from stations distributed over the entire globe. Some of the observers made special observations under trying conditions and with exceptional care. It is not possible here to do more than make general acknowledgment of indebtedness and appreciation for the painstaking efforts and promptness of our collaborators. The data from the contributing stations will be found in various issues of the Journal beginning with December, 1919. Credit is also due the following members of the Department of Terrestrial Magnetism for their effective assistance in the scaling and reducing of magnetograph data, in the computations, and in the construction of the diagrams: J. A. Fleming, H. W. Fisk, W. F. Wallis, C. R. Duvall, C. C. Ennis, G. H. Keulegan, and H. D. Harradon. *After the supplementary and confirmatory results from the solar eclipse of May 29, 1919, there cannot be any doubt that the Earth's magnetic condition is subject to an appreciable magnetic variation during a solar eclipse. Indeed, the greater surprise would be, in view of the existence of the solar-diurnal and lunar magnetic variations, if the gradual withdrawal and restoration of solar radiation during a solar eclipse, in greater or less degree, over nearly one-half of the daylight portion of the Earth, did not give rise to a magnetic variation.*

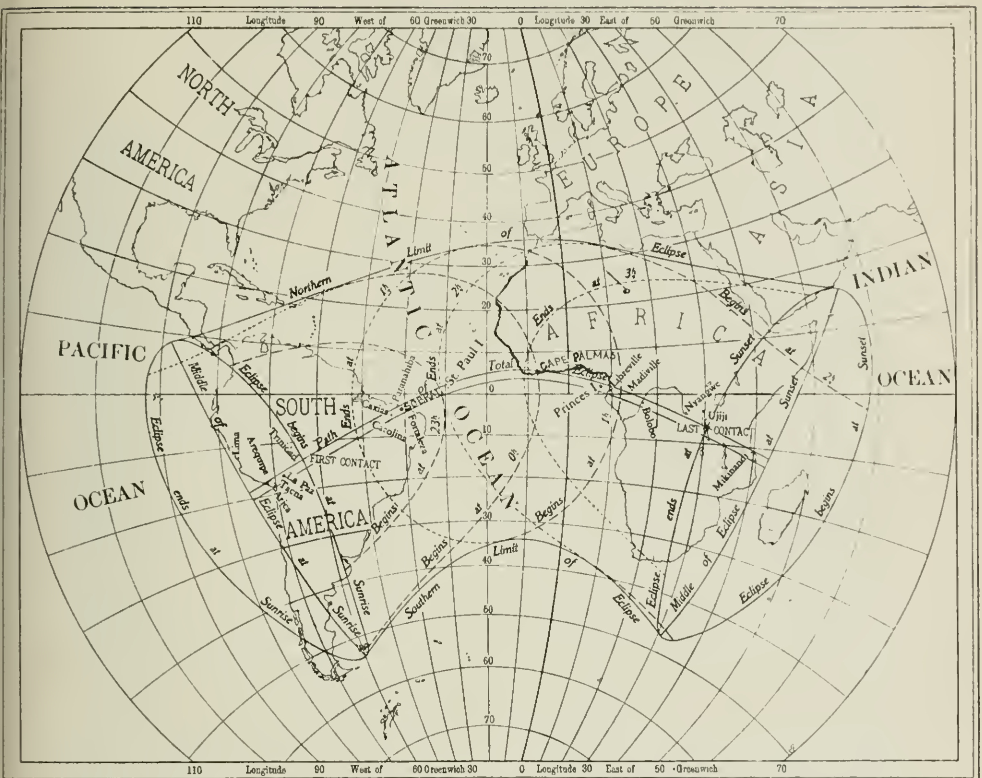

FIG. 1.—THE BELT OF TOTALITY FOR THE SOLAR ECLIPSE OF MAY 29, 1919.
(The hours of beginning and ending are expressed in Greenwich mean time.)

MAGNETIC DATA FOR THE SOLAR ECLIPSE OF MAY 29, 1919.

11. The present summary confines itself chiefly to the magnetic data obtained at the 9 stations (Group I) within the region of visibility of the eclipse. Table I contains the pertinent facts for these stations. Stations 1, 2, 3, 4, and 8, are those of the Department of Terrestrial Magnetism. At Nos. 1 and 2, Huayao, Peru, and Sobral, Brazil (Plate III, Figs. 1 and 2), magnetograph registrations were obtained beginning about 10 days before the day of the eclipse and continuing until about 10 days after. No. 1, north of the totality-belt and practically on the magnetic equator, was in charge of Dr. H. M. W. Edmonds, who was assisted by F. Rosemberg. At No. 2, where the eclipse was total 5.3 minutes, Observer D. M. Wise was in charge, his chief assistant being Andrew Thom-

son: this station was somewhat north of the magnetic equator. No. 3, somewhat south of the magnetic equator, was the writer's station at Cape Palmas, Liberia, where totality lasted 6 minutes and 33 seconds; H. F. Johnston was chief assistant, and G. W. Hutchins, of Cape Palmas, was engaged as a temporary assistant observer. The magnetic observations at No. 3 consisted of declinometer-readings, horizontal-intensity readings with the aid of a specially arranged magnetometer, and earth-inductor readings for inclination changes; the instruments were mounted on the solid concrete floor in the north bay of the vacant stone house formerly occupied by the agent of the Woermánn steamship line (see Pl. III, Fig. 3). The observations for the prescribed eclipse-interval began several days before May 29 and continued throughout May 30. At No. 4, Campo, Cameroons, slightly north of the totality belt, and at No. 8, Deseado, Argentina, near the southern limit of region of visibility of the eclipse, declination-readings were obtained with the survey magnetometers by Observers F. Brown and A. Sterling; the observations were made for the prescribed interval on May 28, 29, and 30. On May 24-25, and June 1-2, 1919, Mr. Brown made declination-readings at Campo for 24 hours for the determination of the normal diurnal variation. At No. 5, Bulawayo, Rhodesia, south of the totality-belt, declination-readings were made for the prescribed interval on May 28, 29, and 30, by Rev. E. Goetz, S. J., using his own magnetometer and following the directions and forms of the Department of Terrestrial Magnetism. For No. 6, Vassouras Magnetic Observatory, Brazil, Director Morize supplied the hourly values of the magnetic elements for May and June, 1919, and a copy of the magnetogram for May 29. At No. 7, Pilar Magnetic Observatory, Argentina, Dr. F. H. Bigelow supplied declination-readings for every minute during the prescribed interval on May 28, 29, and 30, and also copies of magnetograms. For the Porto Rico Magnetic Observatory, almost at the northern limit of the region of visibility, there were furnished by Director Jones of the United States Coast and Geodetic Survey, the mean values for 60-minute intervals of the magnetic elements for May 28-30, 1919, as well as other data. We have thus magnetic data for the region of visibility of the eclipse from 2 stations inside the belt of totality, 3 stations north of, and 4 stations south of the belt. For the purpose of comparison of the data from the eclipse-region with those from two observatories east of the region of visibility, but still in the daylight-region during the eclipse, stations 10 and

11, namely, Mauritius, Indian Ocean, and Dehra Dun, India, have been included in the present summary. At both of these stations extensive observations were made in accordance with the program of the Department of Terrestrial Magnetism (*Terr. Mag.*, vol. 24, 1919, pp. 41-43), and grateful acknowledgment must be made to the respective directors for their valuable data.

TABLE 1.—*Geographic positions of stations, magnetic elements, and eclipse-circumstances, May 29, 1919.*

r.	No.	Station	Geographic Position			Approximate			G.M.T. Loc. Ecl.			Max. Obs.	
			Lat.	Longitude		D	H	Z	Beg.	Mid.	End.	L.M.T.	Mag.
			° ′	° ′	h m	°	cgs	cgs	h m	h m	h m	h m	
I	1	Huayao[1]	12 03S	75 22W	−5 01	+8.2	.298	−.001	11 17	11 29	12 28	6 28	0.79
	2	Sobral[2]	3 42S	40 21W	−2 41	−14.9	.287	+.074	10 45	12 00	13 29	9 19	Tot.
	3	Cape Palmas[2]	4 22N	7 44W	−0 31	−18.0	.298	−.013	11 59	13 37	15 07	13 06	Tot.
	4	Campo	2 21N	9 50E	+0 39	−11.1	.304	−.085	12 54	14 19	15 34	14 58	0.98
	5	Bulawayo[3]	20 09S	28 36E	+1 54	−14.8	.205	−.295	13 30	14 35	15 40	16 29	0.66
	6	Vassouras	22 24S	43 39W	−2 55	−11.2	.245	−.067	10 50	11 53	13 04	8 58	0.53
	7	Pilar[1]	31 40S	63 53W	−4 16	+7.9	.253	−.122	11 08	11 39	12 36	7 23	0.54
	8	Deseado[1]	47 45S	65 55W	−4 24	+14.2	.263	−.252	.....	12 03	12 28	7 39	0.16
	9	Porto Rico	18 09N	65 27W	−4 22	−3.6	.279	+.348	11 36	11 49	12 03	7 27	0.02
II	10	Mauritius	20 06S	57 33E	+3 50	−10.1	.231	−.304	.....	.....	.....	.....	.....
	11	Dehra Dun	30 19N	78 03E	+5 12	+1 9	.330	+.329	.....	.....	.....	.....	.....

[1] Local eclipse began at sunrise (geometric).
[2] Duration of Totality: Sobral, 5m. 3; Cape Palmas, 6m. 6.
[3] Time of ending of local eclipse after sunset (geometric), 15h 33m.

12. Fortunately the 3 days, May 28, 29, and 30, were characterized by magnetic observatories the world over as "magnetically-calm" ones, usually of magnetic character 0, and occasionally 1. An examination of the data showed that generally there was no disturbance of eruptive type though there was at times, especially at certain stations, a quiet, steadily progressive disturbance which, while it affected the absolute values, could readily be largely eliminated. *The mean values for May 28 and 50 were adopted as the normal values, and designated by N.* If the values at corresponding times on May 29 be designated by *29*, then the differences, $\triangle = 29 - N$, were formed for each of the elements D (declination), H (horizontal intensity), Z (vertical intensity), or I (inclination). East D, and Z, and I for north end of dipping needle below the horizon, were regarded as positive. Thus were obtained $\triangle D$, $\triangle H$, $\triangle Z$, or $\triangle I$. After these first differences were corrected for the small progressive disturbance of which there may have been evidence before the eclipse began on May 29, they were

designated, respectively, $\triangle D'$, $\triangle H'$, $\triangle Z'$, or $\triangle I'$. Whenever possible, 5-minute means were formed for each of these quantities centering at every fifth minute from $10^h\ 00^m$ to $16^h\ 30^m$ Greenwich civil mean time, designated G. M. T.

MAGNETIC EFFECTS DURING SOLAR ECLIPSE, MAY 29, 1919.

13. Fig. 2 reproduces the *declination-changes* ($\triangle D'$*-curves*) at the stations for which 5-minute values are at present available. A plus value of $\triangle D'$ signifies an eastward movement of the north end of the compass needle. It will be observed that the first 7 stations were in the region of visibility of the eclipse, the magnitude of maximum obscuration varying from about 1 at Sobral and Cape Palmas to 0.16 at Deseado. The two bottom curves apply to the stations Mauritius and Dehra Dun east of the region of visibility, but in the daylight zone. It is seen at once that the effects are largest for the first 5 stations where the maximum obscuration varied from 0.66 (Bulawayo) upward. Although the maximum obscuration at Pilar was 0.54, the effects are of about the same magnitude as at Deseado (magnitude 0.16), and as at Mauritius and Dehra Dun, which were outside the eclipse zone. The small effects at Pilar are borne out by the hourly values at Vassouras, Brazil, where the maximum obscuration was 0.53, or about the same as at Pilar. The effects, as judged from the 60-minute values, were larger at Porto Rico (magnitude 0.02) than at Pilar and Vassouras. It has been found that the magnitude of the eclipse magnetic effect depends not alone upon the magnitude of maximum obscuration, or upon distance from the totality belt, but also upon the position of the station in the portion of the Earth covered by sunlight at the time of the eclipse, as will be seen more clearly later. At Pilar, according to Table I, the local eclipse began at sunrise (about $7^h\ 27^m$ local mean time) and ended at $8^h\ 20^m$ l. m. t.

14. Another striking thing is the fact that the effects are most symmetrically developed at Cape Palmas, where totality occurred a half hour after the time of central eclipse at local apparant noon, i. e. to say Cape Palmas was just east of the meridian through the most northerly point of the totality belt, termed the central meridian. In Fig. 2, B stands for the beginning of the eclipse on the Earth ($10^h\ 33.5^m$), E, for the ending ($15^h\ 44.0^m$), $C.\ B.$, for time of beginning of central eclipse ($11^h\ 30^m$), M, for time of central

eclipse at local apparent noon (13^h 06.6^s), and C. E., for time of ending of central eclipse (14^h 47.4^m). At Huayao and Sobral, which were west of the central meridian of the totality belt, the curves are most developed during the latter part of the terrestrial, or entire, eclipse-interval (the time from *B* to *E*, or 5^h 10^m). At

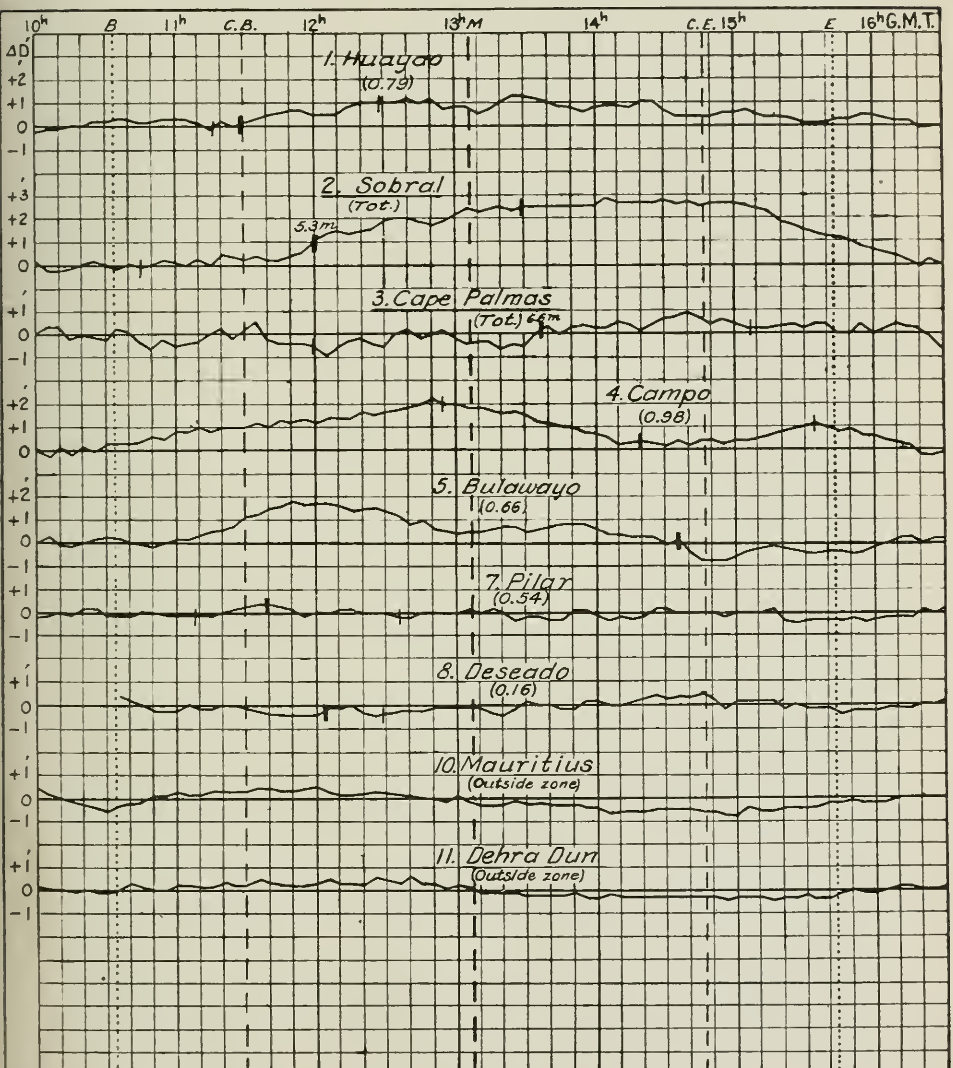

Fig. 2.—Declination-Effects, Solar Eclipse, May 29, 1919.

Campo and Bulawayo, which were east of the central meridian, the curves are best developed during the first half of the terrestrial eclipse-interval. At Cape Palmas, however, the line M almost passes through the point of the curve where the deflection of the compass changes from being generally west to being generally east.

15. Two main waves, with some minor ones, are disclosed by the curves: one, having a period approximately the length of the terrestrial eclipse-interval (5^h 10^m), and the other having a period approximating the average local eclipse-interval (about two hours from first to last contact). For the stations inside or near the belt of totality, the average amplitude (semi-range) of the long wave is about $0'.9$, and that of the short wave about $0.'5$. These amplitudes correspond, respectively, to a deflecting horizontal force of about 6.5γ, and 3.9γ, or 0.01 per cent and 0.006 per cent of the west-east component of the Earth's magnetic system.

16. It seemed at first surprising that the effects at the long totality-station, Cape Palmas, should be small in comparison with those at Huayao, Sobral, Campo, and Bulawayo. However, a preliminary analysis of the magnetic systems causing the effects, of which more will be said later, cleared up the matter. While the curves at Huayao and Sobral run well together, they are at times in opposition to the curves at Campo and Bulawayo, which follow about the same course. The Cape Palmas curve represents a sort of transition-stage from the curves at the two westerly stations to the curves at the two easterly stations. In other words, Cape Palmas being near the central meridian of the belt is in the region about midway between a north-end attracting focus and a south-end attracting focus of the system of forces causing the eclipse magnetic effects.

17. Fig. 3 gives the *horizontal-intensity changes* (*$\triangle H'$-curves*) for stations Nos. 1, 2, 3, 10, and 11, as based upon 15-minute means, centering at every fifteenth minute from 10^h to 16^h 30^m. The data will be found in the next summary. The character of the horizontal-intensity effects during the terrestrial and the local eclipse-intervals are well shown by these curves. The effects are most pronounced and symmetrical at Cape Palmas. At Huayao, Sobral, and Cape Palmas, both the long and short-period waves appear, as in the $\triangle D'$-curves. For the three principal stations (Huayao, Sobral, and Cape Palmas), the average amplitude of the long wave is about 10.6γ, whereas that of the short wave is about

5.0γ, corresponding, respectively, to 0.048 and 0.02 per cent, approximately, of the average value of the horizontal intensity.

18. Fig. 4 presents the *inclination-variations*, $\triangle I'$, during the eclipse-interval. A plus $\triangle I'$ indicates a downward movement of the north end of the dipping needle. It is again found that the effects, as in the case of H (Fig. 3), are largest and most symmetrical for Cape Palmas. It is of interest to note that at the outside stations, Mauritius and Dehra Dun, the effects have almost vanished. At the two totality-stations, Nos. 2 (Sobral) and 3 (Cape Palmas) the curves generally go in opposite directions. Sobral it will be recalled is north of the magnetic equator, whereas Cape Palmas is south of it. Both the long-period and the short-period waves may again be observed. For the three principal stations (Huayao, Sobral, and Cape Palmas), the average amplitude of the long wave is about 0′.8 and that of the short wave is about 0′.4. For the same stations, the average amplitude of the *vertical-intensity effects* ($\triangle Z'$) of the long wave is 6.6γ, and of the short wave 3.0γ, corresponding, respectively, to 0.2 and 0.1 per cent; approximately, of the average vertical intensity.

19. With the aid of the effects $\triangle D'$, $\triangle H'$, $\triangle I'$, the rectangular components $\triangle X'$, $\triangle Y'$, $\triangle Z'$ were computed; X is taken positive towards the north, Y, positive towards the east, and Z, positive vertically downwards. In Fig. 5 will be found the XY-vector diagrams for the three main stations, Huayao, Sobral, and Cape Palmas, as drawn with the aid of the 15-minute values of $\triangle X'$ and $\triangle Y'$. The origin of the co-ordinates in each case marks the geographical location of the station. The relation of the station to the belt of totality and to the magnetic equator may be readily seen. The nearly central position of Cape Palmas, in the belt of totality, is well exhibited by the symmetry with respect to the X-axis of the XY diagram at this station. Huayao and Sobral being west of the central meridian of this belt have their XY-diagrams lying almost entirely east of the X-axis. Since the vector drawn from the origin to the point of the curve gives the direction and magnitude of the deflecting force which acted on the compass needle during the eclipse, we may at once perceive from these vector diagrams the main facts shown by the $\triangle D'$-curves (Fig. 2) and by the $\triangle H'$-curves (Fig. 3), as already stated.

MAGNETIC EFFECTS OUTSIDE ECLIPSE REGION, MAY 29, 1919.

20. It would appear that effects from the eclipse magnetic variation made themselves felt as far north of the region of visibility as Cheltenham, Maryland, and Eskdalemuir, Scotland, and possibly even beyond. It was found that the range of magnetic declination on May 29, 1919, exceeded the mean value for May 28 and 30, for the stations in the Northern Hemisphere, on both sides of the Atlantic, on the average, by about $1'.5$, or about 0.10 of the normal diurnal range. This fact possibly may not be attributable to the eclipse but it is worth while noting the following interesting circumstances. The eclipse took place during the time when the declination needle was passing through the morning, or easterly elongation, at stations along the west Atlantic coast, and through the afternoon, or westerly, elongation at stations along the east Atlantic coast. Now it is found that on May 29, during the eclipse, the needle was swung a trifle further to the east than on the average for May 28 and 30, along the west Atlantic coast, and a trifle further to the west along the east Atlantic coast. In brief, the chief reason for the increased declination range on May 29 is that along the west Atlantic coast as the needle was nearing the usual morning extreme value it was slightly deflected eastward, whereas along the east Atlantic coast as the needle was nearing the customary extreme value of the afternoon it was slightly deflected westward. Such effects did not occur in general at observatories not in the sunlight region when the eclipse occurred, as judged, for example, by the data at Tucson (Arizona), Honolulu, and Watheroo (Western Australia). In a future summary other evidences will be given to show that, when the observing stations were in the daylight zone, effects from the eclipse magnetic variation penetrated to considerable distances beyond the region of visibility of the eclipse.

ANALYSIS OF SOLAR-ECLIPSE MAGNETIC VARIATION, MAY 29, 1919.

21. A preliminary attempt has been made to analyze the magnetic field, which superposed upon the Earth's normal field, gave rise to the observed eclipse magnetic effects shown in Figs. 2-5. Confining attention chiefly at present to the eclipse-region effects, the actuating centers or foci of the systems of disturbing forces prevailing at various times, have been approximately determined by harmonic analysis. The vectors in Fig. 6 show the direction and magnitude of the horizontal disturbing forces at $12^h\ 30^m$

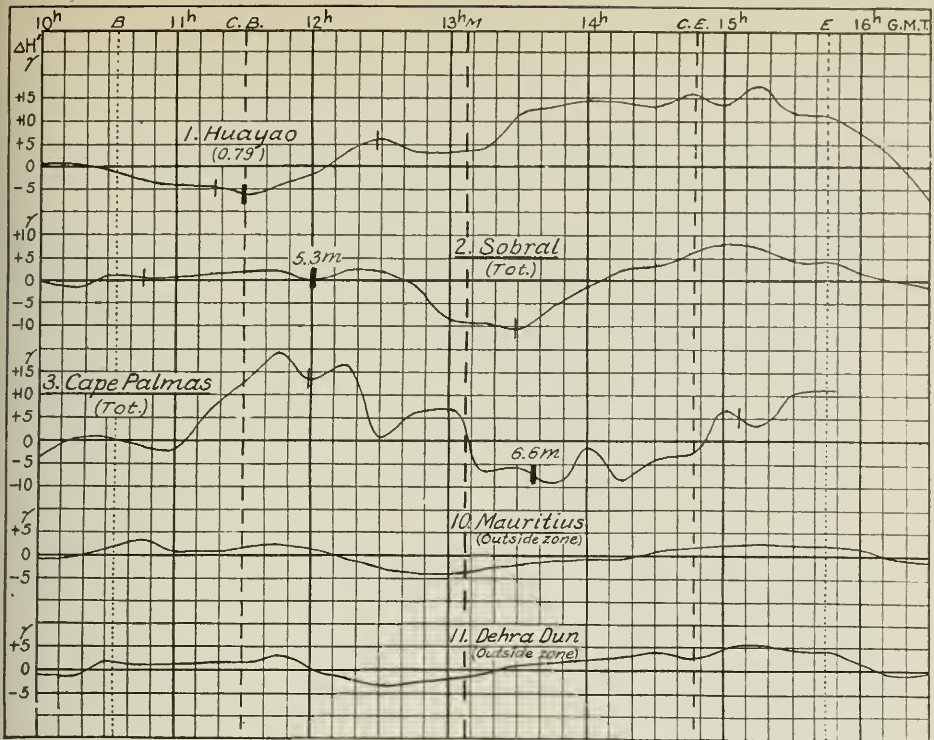

FIG. 3.—HORIZONTAL-INTENSITY EFFECTS, SOLAR ECLIPSE, MAY 29, 1919.

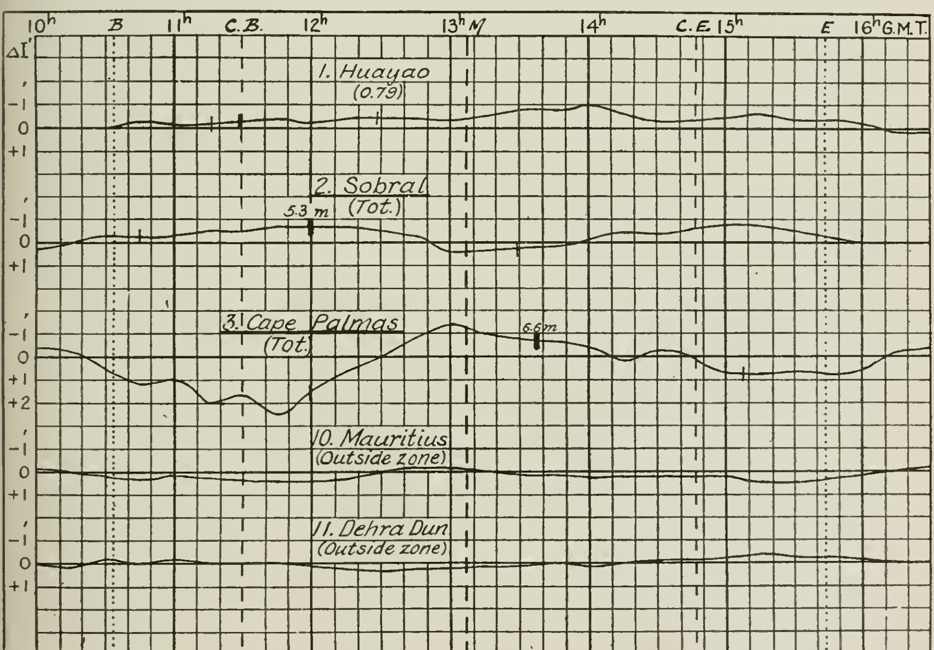

FIG. 4.—INCLINATION-EFFECTS, SOLAR ECLIPSE, MAY 29, 1919.

G. M. T., when the eclipse magnetic system was nearing its maximum development; the vertical-intensity effects, expressed in gammas, are indicated by figures at each station. When the horizontal vectors could be drawn with the aid of data from a 15-minute interval centering at $12^h\ 30^m$, as was the case for the main stations (Huayao, Sobral, and Cape Palmas), they are shown by full lines; at the stations for which the data had to be obtained at present from hourly values, or mean values over a 60-minute interval, as was the case for the auxiliary stations (Vassouras, Porto Rico, Coimbra, and Tortosa), the vectors are shown by broken lines. The table of numerical data will be given in the next summary.

22. It will be seen (Fig. 6) that the vectors for the magnetic system producing the horizontal forces at $12^h\ 30^m$ converge towards a north-end attracting focus, N_h, which is found to be approximately at 8°.2 N and 22°.6 W, or just to the northeast of the point where the axis of the Moon's shadow-cone pierces the Earth, shown by the circle marked M (1°.4 N; 29°.0 W). Since the values of $\triangle Z'$, the vertical-intensity effects, for the stations in or near the totality-belt are negative, indicating that the north-end attracting pole near the Moon's shadow-cone drew the north-end of the dipping needle upward, we have evidence that the eclipse-magnetic system had its seat, partly at least, above the Earth's surface. Analyzing the effects, we find that the north-end attracting focus, N_e of the external system (E), projected on the Earth's surface, was at 2°.9 S and 17°.4 W, or approximately east-southeast of the position of the shadow-cone M, at $12^h\ 30^m$. The external magnetic system was in turn accompanied by an internal magnetic system (I) whose north-end attracting focus, N_i, was found to be approximately at 31°.8 N and 35°.6 W, hence to the northwest of N_e, or approximately towards the point where the Sun and Moon at $12^h\ 30^m$ were in the zenith. Equally interesting results were disclosed at other times, as will be seen in the next communication. For example, at $13^h\ 30^m$ G. M. T. the position of the axis of the shadow-cone, M, was 4°.7 N, 10°.1 W, and that of N_h about 7°.0 N, 7°.1 W (see Fig. 7). The general magnetic effects from the eclipse systems are stated in conclusion c of paragraph 23.

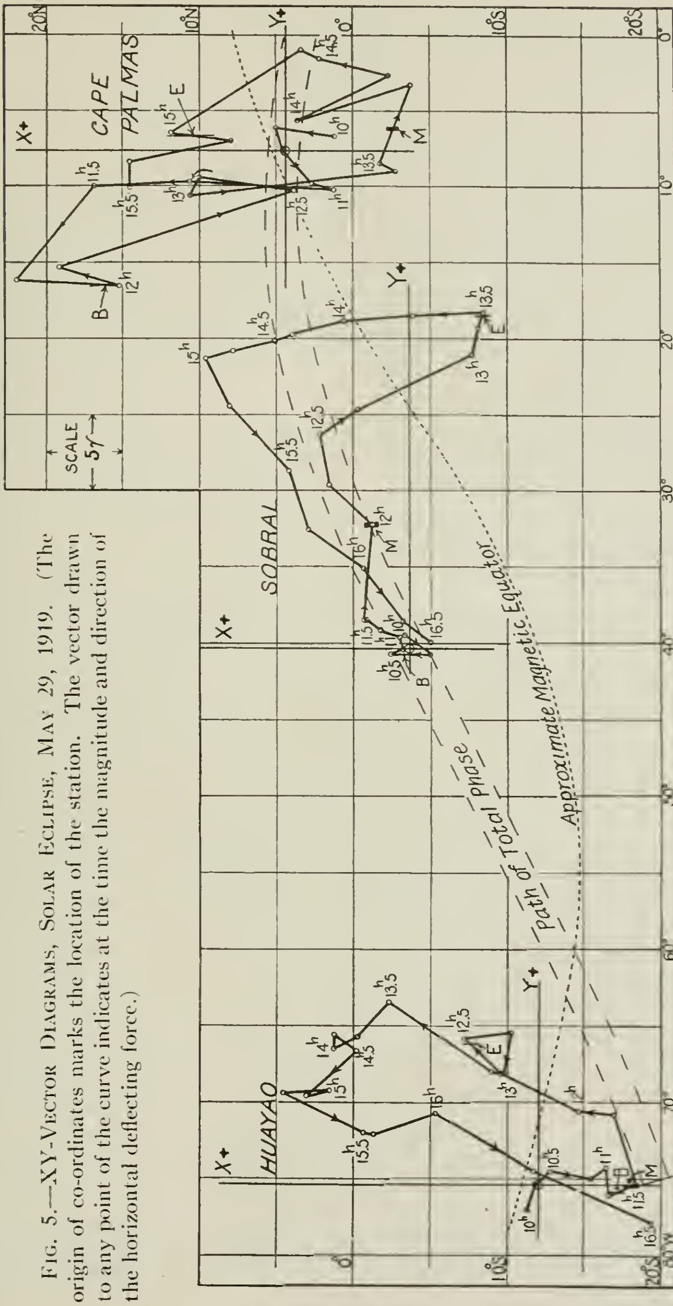

FIG. 5.—XY-VECTOR DIAGRAMS, SOLAR ECLIPSE, MAY 29, 1919. (The origin of co-ordinates marks the location of the station. The vector drawn to any point of the curve indicates at the time the magnitude and direction of the horizontal deflecting force.)

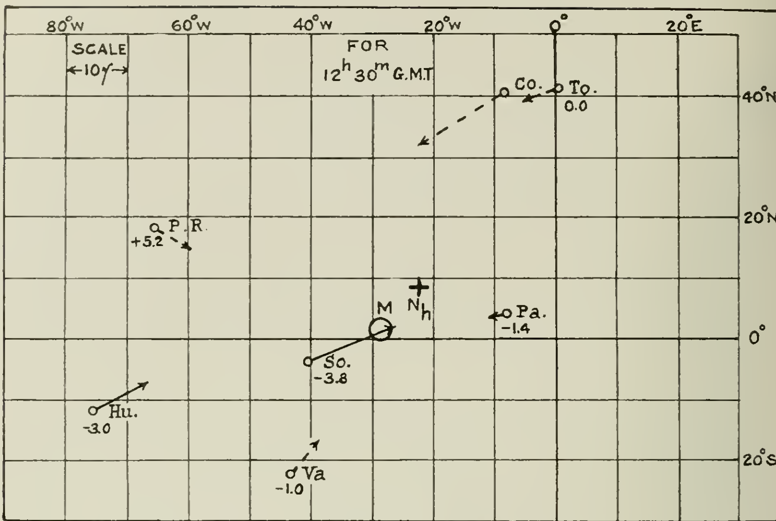

Fig. 6.—For 12ʰ 30ᵐ, G.M.T.

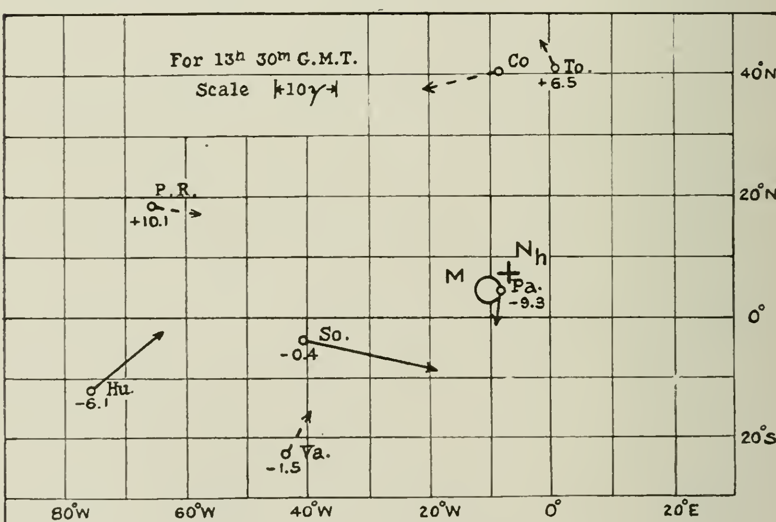

Fig. 7.—For 13ʰ 30ᵐ, G.M.T.

Disturbing Forces Acting on the Compass Needle During the Solar Eclipse, May 29, 1919.

(Note the proximity, in each case, of the north-end attracting focus of the horizontal forces N_h, to the momentary position of the shadow cone, shown by M. The following abbreviations have been used: Hu. = Huayao; So. = Sobral; Pa. = Cape Palmas; Va. = Vassouras; P. R. = Porto Rico; Co. = Coimbra; To. = Tortosa.)

CHIEF CONCLUSIONS FOR SUMMARY I OF MAGNETIC RESULTS.

23. The following are the *main conclusions* which may be drawn at present with the aid of data from 9 stations within the region of visibility and from about 18 stations distributed outside the region:

a. Magnetic effects of appreciable and determinable magnitude were observed during the solar eclipse of May 29, 1919, at stations inside the region of totality as well as at certain stations in the sunlit region, the magnitude and character of the effects being similar to those observed during previous solar eclipses and showing a distinct connection with the eclipse circumstances. The magnetic data for stations in the night region of the globe did not exhibit similar effects.

b. There were two principal variations (with some subordinate ones), as shown especially at stations near the totality-belt, having periods approximating that of the entire eclipse ($5^h\ 10^m$), and that of the local eclipse (on the average about 2 hours from first to last contact). There are evidences that the effects continued for some time after the end of the eclipse at sunset on the southeast coast of Africa. The amplitude (semi-range) of the short wave was, on the average, about one-half of that for the long wave. In the case of the magnetic declination, for example, the amplitude of the long wave for stations inside or near the totality-belt approximated, on the average, one minute of arc, which was equivalent to a horizontal deflecting force of about 0.01 per cent that of the average west-east component of the Earth's magnetism.

c. A preliminary analysis of the magnetic effects at stations within the region of visibility, or in close proximity, showed that the effects in declination and horizontal intensity were similar to those produced by a north-end attracting focus located in the vicinity of the shadow cone. With the aid of the vertical-intensity effects it was found that the eclipse magnetic system was composed of an external and an internal system of forces. At $12^h\ 30^m$ G. M. T., May 29, 1919, just before the maximum development of the eclipse system, the north-end attracting focus of the external system was located east-southeast of the shadow cone, and that of the internal system was to the northward of the cone and approximately northward of the point where the Sun and the Moon were in the zenith. The momentarily increased magnetization of the Earth for stations near the belt of totality of 0.012 per cent at $12^h\ 30^m$

corresponds to the amount associated with about a six per-cent decrease in the solar constant.[12] Equally interesting results were disclosed at other times; invariably the positions of the foci of the disturbing forces could be related to the momentary position of the shadow-cone. The indications are that the complete analysis of the eclipse magnetic system will show that it has characteristics analogous to those exhibited by the systems causing the solar-diurnal and the lunar-diurnal variations of the Earth's magnetism.

[12] *Terr. Mag.*, vol. 20, 1915, p. 149.

(To be continued.)

MAGNETIC OBSERVATIONS AT MAURITIUS, MAY 28–30, 1919.

By A. Walter, *Director.*

In accordance with Dr. Bauer's circular letter of February 19, 1919, there are submitted the results of magnetic and meteorological observations made at the Royal Alfred Observatory, Mauritius, in connection with the solar eclipse of May 29, 1919, which it is hoped will be found serviceable. [Five-minute values of D (declination), H (horizontal intensity), and Z (vertical intensity), from 10^h to $16^h\ 30^m$, G. M. T., were supplied for May 27, 28, 29, 30, and 31. Tables 1, 2, 3, and 4 were derived from these data. *Geographic coordinates*: Latitude 20° 05′.6 S N.; longitude, 57° 33′.2 or $3^h\ 50^m.2$ *E.* —*Ed.*]

Table 1.—*Five-minute values of D, May 28-30, 1919.*

[D = W 10° + tab. quantity; N = mean of May 28 and 30; *29* = May 29.]

G.M.T.	10^h		11^h		12^h		13^h		14^h		15^h		16^h	
	N	29	N	29	N	29	N	29	N	29	N	29	N	29
m	′	′	′	′	′	′	′	′	′	′	′	′	′	′
00	7.6	6.9	6.0	5.5	6.4	5.5	8.0	7.5	9.2	9.1	9.4	9.5	9.9	9.3
05	7.3	6.9	6.0	5.6	6.5	5.9	8.0	7.7	9.3	9.4	9.7	9.5	9.9	9.3
10	7.1	6.9	6.0	5.5	6.6	6.1	8.2	8.1	9.4	9.4	9.7	9.6	10.0	9.3
15	6.9	6.8	6.0	5.3	6.7	6.2	8.4	8.3	9.4	9.4	9.7	9.6	10.0	9.3
20	6.7	6.8	6.0	5.3	6.8	6.2	8.6	8.4	9.4	9.4	9.8	9.6	10.0	9.3
25	6.6	6.8	6.0	5.3	7.0	6.3	8.8	8.5	9.5	9.4	9.8	9.6	10.0	9.3
30	6.4	6.7	6.0	5.3	7.1	6.5	8.8	8.6	9.5	9.4	9.8	9.6	10.0	9.3
35	6.4	6.5	6.1	5.3	7.3	6.8	8.9	8.7	9.5	9.4	9.8	9.5	....	...
40	6.3	6.3	6.1	5.3	7.4	6.9	9.0	8.8	9.5	9.4	9.9	9.5	....	...
45	6.2	6.1	6.1	5.4	7.4	7.0	9.1	8.9	9.5	9.5	9.9	9.5	....	....
50	6.2	5.9	6.2	5.5	7.5	7.1	9.2	9.0	9.5	9.5	9.9	9.4	....	....
55	6.0	5.7	6.3	5.5	7.6	7.3	9.2	9.1	9.4	9.5	9.9	9.4	....	....

Table 2.—*Five-minute values of H, May 28–30, 1919.*

[H = 23050γ + tab. quantity; N = mean of May 28 and 30; *29* = May 29.]

G.M.T.	10^h		11^h		12^h		13^h		14^h		15^h		16^h	
	N	29	N	29	N	29	N	29	N	29	N	29	N	29
m	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
00	72	70	66	65	62	61	64	57	63	59	60	58	61	57
05	72	70	67	65	62	61	64	57	63	59	60	58	61	57
10	72	70	66	65	63	61	65	57	63	59	60	58	61	56
15	71	70	66	65	63	60	64	58	63	58	60	58	61	55
20	71	70	65	64	63	59	64	58	62	58	60	58	61	55
25	70	70	65	64	64	59	63	58	62	59	60	58	61	55
30	70	70	64	64	64	58	63	58	62	59	61	58	61	54
35	69	70	64	64	64	58	64	59	62	58	60	58	..	..
40	68	70	64	64	64	58	64	59	61	58	61	58	..	..
45	68	70	63	63	64	58	63	59	61	59	61	58	..	..
50	67	69	63	62	64	57	64	59	61	59	61	58	..	..
55	66	67	62	62	64	57	63	59	61	58	61	58	..	..

Table 3.—*Five-minute values of Z, May 28-30, 1919.*

[$Z = -30300\gamma$ − tab. quantity; N = mean of May 28 and 30; *29* = May 29.]

G.M.T.	10h		11h		12h		13h		14h		15h		16h	
	N	29	N	29	N	29	N	29	N	29	N	29	N	29
m	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
00	44	57	47	56	53	56	60	63	65	66	66	66	67	67
05	44	56	47	56	54	56	61	63	65	66	66	66	67	67
10	44	56	48	56	54	57	61	63	65	66	67	67	67	67
15	44	56	48	56	55	58	62	64	66	66	67	67	67	67
20	45	56	49	56	56	58	62	64	66	66	67	67	67	67
25	45	55	50	56	56	59	63	64	66	66	67	67	67	67
30	45	55	50	56	57	59	64	64	66	66	67	67	67	67
35	45	55	51	56	58	60	64	65	66	66	67	67	..	..
40	46	55	51	56	58	61	64	65	66	66	67	67	..	..
45	46	55	51	56	58	61	64	65	66	67	67	67	..	..
50	46	55	52	56	59	62	65	66	66	67	67	67	..	..
55	47	56	52	56	60	62	65	66	66	66	67	67	..	..

TABLE 4.—*Five-minute values of* ΔD, ΔH, *and* ΔZ.

[ΔD, or ΔH, or ΔZ = N − 29; West D is minus.]

G.M.T.	10h			11h			12h			13h			14h			15h			16h	
	ΔD	ΔH	ΔZ	ΔD	ΔH	ΔZ	ΔD	ΔH	ΔZ	ΔD	ΔH	ΔZ	ΔD	ΔH	ΔZ	ΔD	HΔ	ΔZ	ΔD	ΔH
m	′	γ	γ	′	γ	γ	′	γ	γ	′	γ	γ	′	γ	γ	′	γ	γ	′	γ
00	+0 7	—2	—13	+0 5	—1	—9	+0.9	—1	—3	+0 5	—7	—3	+0 1	—4	—1	—0 1	—2	0	+0.6	—4
05	+0 4	—2	—12	+0 4	2	—9	+0 6	—1	—2	+0.3	—7	—2	0 1	0 4	—1	+0 2	—2	—1	+0.6	—4
10	+0.2	—2	—12	+0 5	—1	—8	+0 5	2	—3	+0 1	—8	—2	0 0	4	—1	+0 1	—2	0	+0.7	—5
15	+0.1	—1	—12	+0 7	—1	8	+0 5	—3	—3	+0.1	—6	—2	0.0	5	0	+0 1	—2	0	+0.7	—6
20	—0.1	—1	—11	+0 7	1	—7	+0 6	—4	—2	+0 2	—6	—2	0 0	—4	0	+0 2	—2	0	+0.7	—6
25	—0.2	0	—10	+0 7	—1	—6	+0 7	—5	—3	+0 3	—5	—1	+0 1	—3	0	+0 2	—2	0	+0.7	—6
30	—0 3	0	—10	+0.7	0	—6	+0.6	6	—2	+0.2	—5	0	+0 1	—3	0	+0 2	—3	0	+0.7	—7
35	—0.1	+1	—10	+0.8	0	—5	+0.5	—6	—2	+0.2	—5	—1	+0 1	—4	0	+0 3	—2	0	.....	..
40	0.0	+2	—9	+0.8	0	—5	+0.5	—6	—3	+0.2	—5	—1	+0 1	—3	0	+0 4	—3	0	.....	.
45	+0.1	+2	—9	+0.7	0	—5	+0.4	6	3	+0 2	—4	—1	0 0	—2	—1	+0 4	—3	0	.....	.
50	+0.3	+2	—9	+0.7	—1	—4	+0.4	—7	—3	+0.2	—7	—1	0 0	—2	—1	+0 5	—3	0	.....	.
55	+0.3	+1	—9	+0 8	0	—4	+0.3	—7	—2	+0.1	—6	—1	—0 1	—3	0	+0 5	—3	0	.....	

MAGNETIC OBSERVATIONS AT DEHRA DUN, MAY 28–30, 1919.

By Captain E. C. T. Bond, *Officer-in-Charge.*

In response to the co-operation requested by the Department of Terrestrial Magnetism for special simultaneous magnetic observations during the solar eclipse of May 29, 1919, I have the honor to forward abstracts of the declination, horizontal force, vertical force, and dip observations taken at the Dehra Dun Observatory, India, on the 28th, 29th, and 30th, May, 1919, in accordance with the published program. It will be observed that no unusual changes occurred in the magnetic elements during the observations; I hope, however, that these observations will be of use in the investigation of the effects of the eclipse on the Earth's magnetism.

The *geographic position* of the Observatory is: Latitude, 30° 19′.3 N.; longitude, 78° 03′.3 or 5^{h} $12^{m}.2$ E.

Meteorological Notes.—May 28: Calm atmosphere and clear sky in the forenoon; sultry afternoon with cloudy sky. *May 29:* Clear sky and calm atmosphere throughout the day; sultry in the afternoon. *May 30:* Cloudy sky throughout the day; sultry p. m.

TABLE 1.—*Five-minute means of magnetometer values of D and △D.*
[D = E 1° 50′ + ; N = mean of May 28 and 30; *29* = May 29; $\triangle D$ = *29* − N.]

G.M.T.	N	29	$\triangle D$	G.M.T.	N	29	$\triangle D$	G.M.T.	N	29	$\triangle D$
h m	′	′	′	h m	′	′	′	h m	′	′	′
10 00	3.8	3.5	−0.3	12 10	6.0	6.2	+0.2	14 20	5.9	5.7	−0.2
05	4.1	3.7	−0.4	15	6.0	6.2	+0.2	25	6.0	5.8	−0.2
10	4.2	3.8	−0.4	20	6.0	6.2	+0.2	30	6.0	5.8	−0.2
15	4.3	3.8	−0.5	25	6.1	6.5	+0.4	35	6.0	5.8	−0.2
20	4.4	4.0	−0.4	30	6.2	6.5	+0.3	40	6.0	5.8	−0.2
25	4.5	4.0	−0.5	35	6.2	6.4	+0.2	45	6.0	5.8	−0.2
30	4.6	4.1	−0.5	40	6.2	6.7	+0.5	50	6.0	5.8	−0.2
35	4.6	4.2	−0.4	45	6.3	6.5	+0.2	55	6.0	5.8	−0.2
40	4.5	4.4	−0.1	50	6.4	6.6	+0.2	15 00	6.0	5.9	−0.1
45	4.9	4.6	−0.3	55	6.5	6.5	0.0	05	6.0	5.9	−0.1
50	5.0	4.6	−0.4	13 00	6.4	6.5	+0.1	10	6.0	5.9	−0.1
55	5.1	4.8	−0.3	05	6.3	6.4	+0.1	15	6.0	5.8	−0.2
11 00	5.2	5.1	−0.0	10	6.3	6.2	−0.1	20	5.9	5.8	−0.1
05	5.2	5.1	−0.1	15	6.3	6.2	−0.1	25	5.9	5.8	−0.1
10	5.2	5.1	−0.1	20	6.3	6.2	−0.1	30	5.8	5.8	0.0
15	5.3	5.2	−0.1	25	6.2	6.1	−0.1	35	5.9	5.8	−0.1
20	5.4	5.5	+0.1	30	6.2	6.0	−0.2	40	6.0	5.9	−0.1
25	5.5	5.5	0.0	35	6.1	5.9	−0.2	45	5.9	6.0	+0.1
30	5.5	5.5	0.0	40	6.0	5.8	−0.2	50	5.9	6.1	+0.2
35	5.5	5.7	+0.2	45	6.0	5.8	−0.2	55	5.9	6.1	+0.2
40	5.7	5.8	+0.1	50	6.0	5.9	−0.1	16 00	5.9	6.1	+0.2
45	5.7	5.7	0.0	55	6.0	5.8	−0.2	05	5.8	6.1	+0.3
50	5.8	5.8	0.0	14 00	6.0	5.8	−0.2	10	5.8	6.2	+0.4
55	5.8	5.9	+0.1	05	5.9	5.8	−0.1	15	5.8	6.2	+0.4
12 00	5.8	6.0	+0.2	10	5.9	5.7	−0.2	20	5.9	6.2	+0.3
05	5.9	6.2	+0.3	15	5.9	5.7	−0.2	25	5.9	6.2	+0.3
								30	5.9	6.3	+0.4

TABLE 2.—*Five-minute magnetogram values of D and △D.*
[D = E 1° 50′ + ; N = mean of May 28 and 30; *29* = May 29; $\triangle D$ = *29* − N.]

G.M.T.	N	29	$\triangle D$	G.M.T.	N	29	$\triangle D$	G.M.T.	N	29	$\triangle D$
h m	′	′	′	h m	′	′	′	h m	′	′	′
9 58	3.9	3.6	−0.3	12 13	6.0	6.3	+0.3	14 28	6.0	5.8	−0.2
10 03	4.0	3.7	−0.3	18	6.0	6.4	+0.4	33	6.0	5.8	−0.2
08	4.1	3.7	−0.4	23	6.0	6.4	+0.4	38	6.0	5.8	−0.2
13	4.2	3.7	−0.5	28	6.0	6.5	+0.5	43	6.0	5.8	−0.2
18	4.3	3.8	−0.5	33	6.1	6.6	+0.5	48	6.0	5.8	−0.2
23	4.4	4.0	−0.4	38	6.1	6.6	+0.5	53	6.0	5.8	−0.2
28	4.6	4.2	−0.4	43	6.2	6.7	+0.5	58	6.0	5.8	−0.2
33	4.7	4.3	−0.4	48	6.3	6.7	+0.4	15 03	6.0	5.8	−0.2
38	4.7	4.6	−0.1	53	6.4	6.7	+0.3	08	6.0	5.9	−0.1
43	4.8	4.7	−0.1	58	6.3	6.6	+0.3	13	6.0	5.9	−0.1
48	4.9	4.8	−0.1	13 03	6.2	6.5	+0.3	18	5.9	5.9	0.0
53	5.2	4.8	−0.4	08	6.2	6.3	+0.1	23	5.9	5.9	0.0
58	5.3	5.0	−0.3	13	6.2	6.2	0.0	28	5.9	5.9	0.0
11 03	5.3	5.0	−0.3	18	6.2	6.2	0.0	33	5.8	5.8	0.0
08	5.3	5.2	−0.1	23	6.2	6.1	−0.1	38	5.8	5.8	0.0
13	5.3	5.3	0.0	28	6.2	6.0	−0.2	43	5.9	6.0	+0.1
18	5.3	5.5	+0.2	33	6.1	5.9	−0.2	48	5.9	6.0	+0.1
23	5.4	5.5	+0.1	38	6.1	5.9	−0.2	53	5.9	6.0	+0.1
28	5.4	5.6	+0.2	43	6.0	5.8	−0.2	58	5.9	6.1	+0.2
33	5.5	5.7	+0.2	48	6.0	5.8	−0.2	16 03	5.8	6.1	+0.3
38	5.7	5.8	+0.1	53	6.0	5.8	−0.2	08	5.8	6.1	+0.3
43	5.8	5.8	0.0	58	6.0	5.8	−0.2	13	5.8	6.1	+0.3
48	5.8	5.8	0.0	14 03	6.0	5.8	−0.2	18	5.8	6.2	+0.4
53	5.8	5.9	+0.1	08	5.9	5.8	−0.1	23	5.8	6.3	+0.5
58	5.9	5.9	0.0	13	5.9	5.8	−0.1	28	5.8	6.3	+0.5
12 03	5.9	6.1	+0.2	18	6.0	5.8	−0.2	33	5.9	6.4	+0.5
08	6.0	6.3	+0.3	23	6.0	5.8	−0.2				

TABLE 3.—*Five-minute magnetogram values of H and △H.*
[$H = 32900\gamma +$; N = mean of May 28 and 30; *29* = May 29; $\triangle H = 29 - N$.]

G.M.T.	N	29	$\triangle H$	G.M.T.	N	29	$\triangle H$	G.M.T.	N	29	$\triangle H$
h m	γ	γ	γ	h m	γ	γ	γ	h m	γ	γ	γ
9 58	79	78	−1	12 13	64	62	−2	14 28	60	63	+3
10 03	80	78	−2	18	64	62	−2	33	60	63	+3
08	80	77	−3	23	64	62	−2	38	60	62	+2
13	78	77	−1	28	65	59	−6	43	61	62	+1
18	78	75	−3	33	65	59	−6	48	62	63	+1
23	76	75	−1	38	63	59	−4	53	62	66	+4
28	74	76	+2	43	63	59	−4	58	62	65	+3
33	73	75	+2	48	62	58	−4	15 03	62	65	+3
38	72	73	+1	53	62	58	−4	08	61	65	+4
43	71	73	+2	58	62	59	−3	13	62	66	+4
48	70	68	−2	13 03	62	59	−3	18	62	66	+4
53	69	69	0	08	62	59	−3	23	64	67	+3
58	69	69	0	13	62	60	−2	28	63	66	+3
11 03	68	68	0	18	62	60	−2	33	64	67	+3
08	68	69	+1	23	61	61	0	38	64	67	+3
13	68	69	+1	28	62	60	−2	43	64	67	+3
18	67	67	0	33	62	62	0	48	65	68	+3
23	67	67	0	38	62	63	+1	53	64	66	+2
28	67	67	0	43	61	62	+1	58	64	66	+2
33	66	67	+1	48	61	60	−1	16 03	65	64	−1
38	65	66	+1	53	60	60	0	08	66	63	−3
43	65	67	+2	58	60	60	0	13	66	63	−3
48	64	67	+3	14 03	60	63	+3	18	65	63	−2
53	64	66	+2	08	60	63	+3	23	64	64	0
58	65	64	−1	13	60	62	+2	28	65	65	0
12 03	65	64	−1	18	60	60	0	33	67	64	−3
08	65	62	−3	23	60	62	+2				

TABLE 4.—*Five-minute magnetogram values of Z and △Z.*
[$Z = 32800\gamma +$; N = mean of May 28 and 30; *29* = May 29; $\triangle Z = 29 - N$.]

G.M.T.	N	29	$\triangle Z$	G.M.T.	N	29	$\triangle Z$	G.M.T.	N	29	$\triangle Z$
h m	γ	γ	γ	h m	γ	γ	γ	h m	γ	γ	γ
9 58	58	61	+3	12 13	59	65	+6	14 28	57	62	+5
10 03	58	61	+3	18	59	65	+6	33	57	62	+5
08	59	61	+2	23	59	65	+6	38	58	62	+4
13	59	61	+2	28	59	64	+5	43	58	63	+5
18	59	62	+3	33	59	63	+4	48	58	63	+5
23	59	62	+3	38	59	63	+4	53	58	63	+5
28	59	63	+4	43	58	63	+5	58	59	63	+4
33	59	63	+4	48	58	63	+5	15 03	58	63	+5
38	59	63	+4	53	58	63	+5	08	58	63	+5
43	59	63	+4	58	57	63	+6	13	58	63	+5
48	59	62	+3	13 03	58	63	+5	18	58	63	+5
53	59	62	+3	08	58	63	+5	23	58	63	+5
58	59	62	+3	13	57	63	+6	28	58	63	+5
11 03	59	62	+3	18	57	63	+6	33	58	63	+5
08	59	63	+4	23	56	63	+7	38	59	63	+4
13	59	64	+5	28	57	62	+5	43	59	63	+4
18	59	64	+5	33	58	62	+4	48	59	63	+4
23	59	64	+5	38	58	63	+5	53	59	63	+4
28	59	64	+5	43	58	63	+5	58	59	63	+4
33	59	65	+6	48	57	63	+6	16 03	59	63	+4
38	59	65	+6	53	56	63	+7	08	59	63	+4
43	59	65	+6	58	56	63	+7	13	60	63	+3
48	58	65	+7	14 03	56	63	+7	18	60	63	+3
53	58	65	+7	08	56	63	+7	23	60	63	+3
58	58	65	+7	13	56	63	+7	28	60	63	+3
12 03	59	65	+6	18	56	63	+7	33	60	63	+3
08	59	65	+6	23	57	63	+6				

MAGNETIC OBSERVATIONS AT COIMBRA, MAY 1919.

By A. Ferraz de Carvalho, *Director.*

[The readings of the magnetographs were made by the same observers. The data supplied consisted of absolute values of declination (D) and horizontal intensity (H) for each minute from $9^h\ 58^m$ to $16^h\ 32^m$, G. M. T., May 29, 1919; the five-minute means are given in Table 1. Furthermore the hourly values of D and H, local mean time, were supplied for the "five least-disturbed days", May 1, 7, 11, 28, and 30, as well as for May 29; the mean hourly values, D_n and H_n for May 28 and 30 are given in Table 2. Table 3 contains the differences, $\triangle D$ and $\triangle H$, formed from Table 2, by subtraction of the hourly values for May 29 from D_n and H_n, respectively, taking west D as minus. There are some small disturbances noticeable on the supplied magnetograms, approximately of 30-minute period, which are caused by electric tramways about 900 meters distant from the observatory. On account of this disturbance no use of the vertical-intensity register has been made for seven years; a new site is under consideration. Five-minute meteorological observations from $9^h\ 50^m$ to $16^h\ 33^m$, G. M. T., May 29 were also furnished. *Geographic position*: Latitude, 40° 12′ N.; longitude, 8° 25′.4 or $33^m.7$ W.—*Ed.*]

Table 1.—*Five-minute values of D and H, May 29, 1919.*

G.M.T.	D = W 15° 24′ + tab. quantity.							H = 23000γ + tab. quantity.							G.M.T.
	10^h	11^h	12^h	13^h	14^h	15^h	16^h	10^h	11^h	12^h	13^h	14^h	15^h	16^h	
m	′	′	′	′	′	′	′	γ	γ	γ	γ	γ	γ	γ	m
00	0.4	3.3	6.2	8.4	8.9	8.0	6.6	60	63	70	68	68	67	63	00
05	0.6	3.8	6.6	8.5	8.9	7.8	6.4	60	64	70	68	69	67	63	05
10	0.9	4.1	7.0	8.5	8.9	7.9	6.1	61	65	70	68	69	66	61	10
15	1.1	4.4	7.2	8.3	8.4	7.7	6.1	61	66	71	68	68	66	62	15
20	1.4	4.5	7.3	8.4	8.6	7.6	5.9	61	67	70	69	68	66	60	20
25	1.6	4.6	7.6	8.8	8.4	7.4	5.7	61	66	70	68	68	65	59	25
30	2.0	4.8	7.9	8.9	8.4	7.3	5.7	61	67	69	68	68	64	58	30
35	2.2	5.1	8.2	9.0	8.4	7.2	...	61	67	69	68	68	64	..	35
40	2.4	5.5	8.1	9.0	8.5	7.2	...	61	69	69	68	68	64	..	40
45	2.6	5.7	7.8	9.0	8.4	6.9	...	63	70	69	68	70	65	..	45
50	3.0	5.8	8.3	9.0	8.2	6.5	...	62	70	69	68	70	65	..	50
55	3.2	6.0	8.3	9.0	8.1	6.7	...	63	69	69	67	68	65	..	55

Table 2.—*Hourly values of D and H, local mean time.*

L.M.T.	W 15° 20′ +		23000γ+		L.M.T.	W 15° 20′ +		23000γ+		L.M.T.	W15° 20′ +		23000γ+	
	D_n	D_{29}	H_n	H_{29}		D_n	D_{29}	H_n	H_{29}		D_n	D_{29}	H_n	H_{29}
h	′	′	γ	γ	h	′	′	γ	γ	h	′	′	γ	γ
1	6.3	5.6	53	55	9	1.9	03.3	54	61	17	6.6	7.5	64	56
2	5.8	5.6	52	55	10	4.0	06.3	59	64	18	5.7	6.7	67	53
3	5.2	5.6	54	57	11	6.5	09.2	68	68	19	5.7	6.5	63	54
4	4.5	5.0	52	61	12	7.6	12.1	69	69	20	6.1	6.5	66	63
5	3.9	3.9	55	65	13	9.4	13.1	62	68	21	6.4	6.4	64	68
6	2.3	2.8	53	60	14	9.8	12.5	55	67	22	6.5	6.2	65	72
7	1.4	1.1	52	61	15	9.2	11.2	49	64	23	6.4	6.5	64	72
8	1.2	1.1	52	60	16	8.8	10.3	52	55	24	5.9	6.2	58	71

Table 3.—*Hourly values of △D and △H, local mean time.*
[Differences: May 29 − mean of May 28 and 30.]

L.M.T.	△D	△H	L.M.T.	△D	△H	L.M.T.	△D	△H
h	′	γ	h	′	γ	h	′	γ
1	+0.7	+2	09	−1.4	+7	17	−0.9	−8
2	+0.2	+3	10	−2.3	+5	18	−1.0	−14
3	−0.4	+3	11	−2.7	0	19	0.8	−9
4	−0.5	+9	12	−4.5	0	20	−0.4	−3
5	0.0	+10	13	−3.7	+6	21	0.0	+4
6	−0.5	+7	14	−2.7	+12	22	+0.3	+7
7	+0.3	+9	15	−2.0	+15	23	−0.1	+8
8	+0.1	+8	16	−1.5	+3	24	−0.3	+13

Table 4.—*Diurnal variation, dD and dH, local mean time.*
[*M* . mean of 5 quiet days in May; *N* : mean of May 28 and 30; *29*: May 29.]

L.M.T.	Decl'n M	Decl'n N	Decl'n 29	Hor. Int. M	Hor. Int. N	Hor. Int. 29
h	′	′	′	γ	γ	γ
1	+0.3	−0.6	+1.1	−5	−5	−7
2	+0.4	−0.1	+1.1	−7	−6	−7
3	+0.7	+0.5	+1.1	−6	−4	−5
4	+1.2	+1.2	+1.7	−5	−6	−1
5	+1.6	+1.8	+2.8	−4	−3	+3
6	+2.8	+3.4	+3.9	−5	−5	−2
7	+3.6	+4.3	+5.6	−4	−6	−1
8	+3.5	+4.5	+5.6	−2	−6	−2

L.M.T.	Decl'n. M	Decl'n. N	Decl'n. 29	Hor. Int. M	Hor. Int. N	Hor. Int. 29
h	′	′	′	γ	γ	γ
09	+3.1	+3.8	+3.4	−1	−4	−1
10	+1.0	+1.7	+0.4	+3	+1	+2
11	−0.9	−0.8	−2.5	+7	+10	+6
12	−2.3	−1.9	−5.4	+8	+11	+7
13	−3.6	−3.7	−6.4	+6	+4	+6
14	−3.6	−4.1	−5.8	−2	−3	+5
15	−3.1	−3.5	−4.5	−7	−9	+2
16	−2.5	−3.1	−3.6	−2	−6	−7

L.M.T.	Decl'n. M	Decl'n. N	Decl'n. 29	Hor. Int. M	Hor. Int. N	Hor. Int. 29
h	′	′	′	γ	γ	γ
17	−1.3	−0.9	−0.8	+2	+6	−
18	−0.5	0.0	0.0	+4	+9	−
19	−0.4	0.0	+0.2	+3	+5	−
20	−0.3	−0.4	+0.2	+4	+8	+
21	−0.3	−0.7	+0.3	+3	+6	+
22	−0.2	−0.8	+0.5	+4	+7	+1
23	+0.2	−0.7	+0.2	+10	+6	+1
24	+0.5	−0.2	+0.5	+7	0	+

Table 5.—*Declination extreme values and ranges, and daily means, May, 1919.*

1919	L.M.T.	Decl'n.	L.M.T.	Decl'n.	Range	Mean *D*	Mean *H*
	h	° ′	h	° ′	′	° ′	γ
May 1	7.0	15 23.3W	14.6	15 31.8W	8.5	15 26.7W	23059
7	7.5	22.8W	13.7	30.5W	7.7	26.2W	43
11	7.5	23.0W	12.3	29.3W	6.3	26.0W	60
28	7.0	22.8W	12.8	29.6W	6.8	25.8W	52
30	8.0	19.4W	14.0	31.2W	11.8	25.6W	66
Mean (*M*)	7.4	22.3W	13.5	30.5W	8.2	26.1W	56
Mean (*N*)	7.5	21.1W	13.4	30.4W	9.3	25.7W	59
May 29	7.4	20.9W	13.3	33.3W	12.4	26.7W	62

[*Conclusions.* *a*. According to Table 3 the maximum hourly difference, L. M. T., between May 29 and the adopted normal value (mean of May 28 and 30) for *D* is − 4.′5 at 12^h, and for *H* it is + 15γ at 15^h; hence the maximum differences occur during the period of the solar eclipse. *b*. Table 5 shows that the diurnal range in declination was larger on May 29 than for the 5 quiet days (*M*) during May, as also for the 2 quiet days, May 28 and 30 (*N*).—*Ed.*]

OBSERVATIONS IN THE AZORES, MAY 28–30, 1919.

By Col. F. A. Chaves, *Director*.

Special magnetic observations were made in this Island of S. Miguel (Azores) during the solar eclipse of May 29, 1919, in accordance with the program of the Department of Terrestrial Magnetism.

In the garden of my house I have, since 1899, a pier on which I make absolute measurements of the magnetic elements, to compare with those observed at the Magnetic Observatory of S. Miguel, established near Ponta Delgada, under my general direction. In this garden I have also a Mascart declinometer, with which on May 29, during the interval of $9^h\ 58^m$ to $16^h\ 32^m$, Greenwich civil mean time, were made at every minute observations of the declination. Since the results of these eye-readings of the declination agree perfectly with those of the eye-readings, made with a similar instrument at the Magnetic Observatory, only the results of the latter observations are given here. [Table 1 contains the five-minute means.]

Owing to scanty supply of photographic paper, the sheets were cut in two pieces, and for that reason we have only the record of the declinometer, and not the sheet complete with the register of the bifilar and balance. However, eye-readings of the bifilar and of the balance were made on May 29 every minute during the prescribed interval of $9^h\ 58^m$ to $16^h\ 32^m$, G. M. T.; but the day was so calm that it is deemed unnecessary to supply the results of these observations.

The data transmitted accordingly are: 1. Eye-reading observations made at the Magnetic Observatory with a Mascart declinometer, during the above-indicated interval of time, and a diagram of these observations. [Table 1 contains the five-minute means.] At the end of these observations, absolute measurements were made at the Magnetic Observatory and at Ponta Delgada on May 29, 1919. 2. A diagram of the changes in the declination given by the magnetograph of the Magnetic Observatory from May 28–30, 1919. It shows the great magnetic calm of these three days. The recording speed was constant, viz., 15 mm. per hour; 1 mm. ordinate corresponded to $1'.24$. All the hours indicated are corrected after comparison with signals given by the chronometric station established in the Meteorological Observatory of Ponta Delgada. [The results of some scalings of this diagram are given in Tables 2 and 3.] 3. Meteorological observations made at the Meteorological Observatory of Ponta Delgada (nearly five kilometers S. S. W. of the Magnetic Observatory) from May 28 to 30, 1919, and a diagram of these observations. [Table 3 gives an abstract of these observations.]

The *approximate magnetic elements* at the *Magnetic Observatory* for May 29, 1919, are: $D = 19°.4$ W.; $I = 60°.5$ N.; $H = 0.231$; $Z = +0.408$; $F = 0.469$, C. G. S.

The *geographic coordinates for the Magnetic Observatory* are: Latitude, 37° 46′.4 N.; longitude, 25° 39′.2 or $1^h\ 42^m.6$ W.; altitude, 175 meters.

TABLE 1.—*Five-minute means of declination, May 29, 1919.*
[Based upon single-minute eye-readings.]

G.M.T.	D = W 19° 10′ +							G.M.T.
	10^h	11^h	12^h	13^h	14^h	15^h	16^h	
m	′	′	′	′	′	′	′	m
00	11.2	14.8	16.9	18.7	18.8	19.5	20.2	00
05	11.5	14.8	17.0	18.8	18.8	19.7	20.0	05
10	11.7	14.8	17.0	18.8	18.8	19.8	20.0	10
15	12.2	15.0	17.0	18.8	18.8	20.0	19.8	15
20	12.5	15.2	17.0	18.8	18.8	20.0	19.8	20
25	12.7	15.5	17.1	18.8	18.8	20.0	19.8	25
30	12.8	15.6	17.2	18.8	18.8	20.2	19.8	30
35	13.1	15.8	17.6	18.8	19.0	20.2	....	35
40	13.3	16.1	17.8	18.8	19.1	20.2	....	40
45	13.8	16.3	18.0	18.8	19.4	20.3	....	45
50	14.2	16.5	18.2	18.8	19.4	20.3	....	50
55	14.6	16.7	18.5	18.8	19.4	20.4	....	55

TABLE 2.—*Approximate hourly values of D and diurnal variation, dD.*
[Scaled from copies of declination curves.]

G.M.T.	*D* = W19°10′+		*dD*		G.M.T.	*D* = W19°10′+		*dD*	
	N	29	*N*	29		*N*	29	*N*	29
h	′	′	′	′	h	′	′	′	′
1	15.0	14.9	−0.3	+0.8	13	16.3	18.9	−1.6	−3.2
2	15.1	15.3	−0.4	+0.4	14	17.4	19.4	−2.7	−3.7
3	14.9	15.2	−0.2	+0.5	15	17.7	20.1	−3.0	−4.4
4	14.9	15.3	−0.2	+0.4	16	18.1	20.5	*−3.4*	*−4.8*
5	14.9	15.0	−0.2	+0.7	17	17.0	20.0	−2.3	−4.3
6	14.3	13.8	+0.4	+1.9	18	16.2	18.8	−1.5	−3.1
7	12.7	12.4	+2.0	+3.3	19	15.7	17.3	−1.0	−1.6
8	10.3	10.3	+4.4	+5.4	20	14.7	15.2	0.0	+0.5
09	09.9	10.3	**+4.8**	**+5.4**	21	14.5	15.0	+0.2	+0.7
10	11.1	12.3	+3.6	+3.4	22	15.2	14.9	−0.5	+0.8
11	12.9	15.3	+1.8	+0.4	23	14.5	14.5	+0.2	+1.2
12	14.2	17.5	+0.5	−1.8	24	14.4	15.0	+0.3	+0.7

TABLE 3.—*Extreme values, ranges, and daily means, May 28-30, 1919.*
[From scalings of copies of declination curves.]

1919	G.M.T.	Decl'n	G.M.T.	Decl'n.	Range	Daily Mean
	h	° ′	h	° ′	′	° ′
May 28	8.5	19 19.3W	16.3	19 27.6W	8.3	19 14.3W
30	8.7	19.7W	15.7	29.5W	9.8	15.1W
Mean	8.6	19.5W	16.0	28.6W	9.1	14.7W
May 29	8.4	19.8W	15.7	31.0W	11.2	15.7W

[It will be observed that the diurnal range of declination is somewhat larger on May 29 than on the preceding and following days.—*Ed.*]

TABLE 4.—*Meteorological observations at Meteorological Observatory.*

[Barometric pressure (at 0° C. and reduced to sea level and latitude 45°), temperature, direction and velocity of wind in kilometers per hour, May 28-30, 1919, at the Meteorological Observatory of Ponta Delgada, S. Miguel, Azores (Lat. 37° 44'.3 N.; Long. 25° 39'.9 W.]

Greenwich mean time	May 28				May 29				May 30			
	Bar. Press.	Temp. (Cent)	Wind		Bar. Press.	Temp. (Cent)	Wind		Bar. Press.	Temp. (Cent)	Wind	
			Dir.	Vel.			Dir.	Vel.			Dir.	Vel.
h	mm	°		km	mm	°		km	mm	°		km
0	762.6	15.8	WNW	4	763.9	15.6	WNW	8	764.5	16.5	W	6
1	762.5	15.8	NW	3	763.6	15.7	WNW	6	764.4	16.5	W	7
2	762.4	15.1	NW	5	763.2	16.0	WNW	4	764.2	16.7	SW	5
3	762.3	14.7	NW	7	762.9	16.2	WNW	7	764.0	16.7	SW	6
4	762.2	15.0	NW	8	762.9	16.1	WNW	7	763.7	16.7	SW	5
5	762.1	14.5	NW	6	762.7	16.0	WNW	8	763.7	16.6	SW	6
6	762.3	15.0	NW	6	762.6	16.1	WNW	11	763.4	16.6	SW	5
7	762.5	15.5	NW	7	762.6	16.2	WNW	10	763.7	16.6	SW	4
8	762.7	15.5	NW	10	762.7	16.3	WNW	5	764.2	16.6	SW	4
9	762.9	16.3	NW	8	762.9	16.5	WNW	6	764.5	16.7	SW	4
10	763.2	16.9	WNW	10	763.3	16.8	WNW	5	764.8	16.7	SW	5
11	763.3	16.9	WNW	9	763.6	16.8	WNW	9	764.9	17.3	SW	6
12	763.5	17.0	WNW	9	763.6	17.0	WNW	8	765.1	17.4	SW	6
13	763.4	17.3	WNW	10	763.7	17.2	W	9	765.1	17.4	SW	6
14	763.4	17.0	WNW	13	763.7	17.4	W	9	764.9	17.4	SW	6
15	763.7	17.3	WNW	13	763.6	17.4	W	7	764.9	17.5	SW	6
16	763.6	17.3	WNW	13	763.6	17.3	W	10	764.9	17.7	SW	8
17	763.6	16.0	WNW	13	763.5	17.9	W	7	764.8	17.9	SW	9
18	763.6	16.2	WNW	12	763.5	17.4	W	21	764.7	17.7	SW	8
19	763.5	16.5	WNW	12	763.7	17.0	W	17	764.7	18.0	WSW	8
20	763.4	16.2	WNW	11	763.8	16.8	W	9	764.7	17.6	WSW	6
21	763.4	16.0	WNW	10	764.1	16.6	W	5	764.9	17.2	W	4
22	763.5	15.8	WNW	8	764.3	16.5	W	9	765.2	17.1	W	4
23	763.8	15.5	WNW	9	764.4	16.5	W	7	765.6	17.0	W	3
24	....	....	......	....	.....	....	......	..	765.7	17.0	W	4

MAGNETIC OBSERVATIONS AT BULAWAYO, MAY 28–30, 1919.

BY REV. E. GOETZ, S. J

Below are given the results of the magnetic observations which I took on May 28, 29, and 30, 1919, in connection with the solar eclipse of May 29, 1919, and in accordance with the program and forms received from the Department of Terrestrial Magnetism.

I think I made a mistake in undertaking too much. After sixteen years of continued stay in this country one ought not to do things which are quite possible to a younger man and not expect to feel it. On the 29th I was very tired. I had given up the idea of taking contact observations. At the last moment a friend offered to take them, and I tried to get my telescope ready for him. Unhappily the 29th turned out to be a cloudy day. From 9 to 11 o'clock (local time), I tried in vain to focus my telescope for him at rare moments when I got a fleeting glimpse of the Sun. At

eleven I gave it up and went back to my magnetic hut. I found the fiber broken. I had prepared for this emergency. But as the morning was very windy the new fiber developed a twist which took the better part of the hour to get rid of. In consequence I fear my preliminary determinations were rather hurried.

[The data supplied for Bulawayo Observatory, Rhodesia, South Africa, consisted of magnetometer eye-reading values of D (declination) for every minute during the prescribed interval on the three days, May 28–30, 1919. It may be stated that the preliminary observations on May 29 were begun sufficiently early to offset the loss of time caused by the breaking of the fiber. The torsion-effect experiments at the beginning and end of the observations were in good agreement. There was a change of 46° in the plane of detorsion, the total torsion-effect amounting to but 1′.6, which was distributed uniformly over the observation-interval. The *geographic coordinates* are: Latitude, 20° 09′.1 S.; longitude, 28° 36′.3 or 1^h 54.4^m E. The *approximate circumstances of the eclipse* were for Greenwich civil mean time: Beginning, 13^h 30^m; middle, 14^h 35^m; ending, 15^h 40^m (after sunset, 15^h 33^m); magnitude of maximum observation, 0.66.—*Ed.*]

Table 1.—*Five-minute means of D, May 28-30, 1919.*

[D = W 14° 40′ + tabular quantity; N = mean of May 28 and 30; *29* = May 29; $\triangle D$ = *29* − N, west D being minus.]

G.M.T.	D: N	D: 29	Diff. $\triangle D$	G.M.T.	D: N	D: 29	Diff. $\triangle D$	G.M.T.	D: N	D: 292	Diff. $\triangle D$
h m	′	′	′	h m	′	′	′	h m	′	′	′
10 00	13.0	12.7	+0.3	12 10	09.0	07.0	+2.1	14 20	08.3	07.4	−0.9
05	12.7	12.2	+0.5	15	08.8	06.9	+1.9	25	08.5	07.7	+0.8
10	12.4	12.2	+0.2	20	08.7	06.7	+2.0	30	08.6	08.0	+0.6
15	12.2	12.0	+0.2	25	08.6	06.6	+2.0	35	08.8	08.0	+0.8
20	12.1	11.8	+0.3	30	08.4	06.5	+1.9	40	08.9	08.6	+0.3
25	11.9	11.5	+0.4	35	08.2	06.6	+1.6	45	09.0	09.0	0.0
30	11.8	11.3	+0.5	40	07.9	06.5	+1.4	50	09.0	09.0	0.0
35	11.6	11.2	+0.4	45	07.7	06.2	+1.5	55	09.2	09.2	0.0
40	11.4	11.3	+0.3	50	07.4	06.3	+1.1	15 00	09.4	09.3	+0.1
45	11.3	11.1	+0.2	55	07.4	06.4	+1.0	05	09.7	09.3	+0.4
50	11.1	10.9	+0.2	13 00	07.3	06.4	+0.9	10	10.1	09.6	+0.5
55	11.0	10.7	+0.3	05	07.3	06.3	+1.0	15	10.5	09.8	+0.7
11 00	11.0	10.6	+0.4	10	07.3	06.3	+1.0	20	10.7	10.1	+0.6
05	11.0	10.5	+0.5	15	07.4	06.3	+1.1	25	10.8	10.3	+0.5
10	10.9	10.2	+0.7	20	07.4	06.2	+1.2	30	11.0	10.6	+0.4
15	10.8	09.9	+0.9	25	07.4	06.2	+1.2	35	11.1	10.7	+0.4
20	10.7	09.7	+1.0	30	07.4	06.3	+1.1	40	11.2	10.7	+0.5
25	10.6	09.4	+1.2	35	07.5	06.3	+1.2	45	11.2	10.7	+0.5
30	10.6	09.1	+1.5	40	07.6	06.3	+1.3	50	11.3	10.8	+0.5
35	10.4	08.8	+1.6	45	07.7	06.3	+1.4	55	11.6	11.0	+0.6
40	10.3	08.4	+1.9	50	07.6	06.2	+1.4	16 00	11.6	10.8	+0.8
45	10.1	08.1	+2.0	55	07.7	06.3	+1.4	05	11.6	10.7	+0.9
50	10.0	07.8	+2.2	14 00	07.8	06.6	+1.2	10	11.7	10.6	+1.1
55	09.7	07.7	+2.0	05	08.0	07.0	+1.0	15	11.6	10.6	+1.1
12 00	09.5	07.4	+2.1	10	08.1	07.1	+1.0	20	11.5	10.5	+1.0
05	09.3	07.1	+2.2	15	08.2	07.3	+0.9	25	11.5	10.4	+1.1
10	09.1	07.0	+2.1	20	08.3	07.4	+0.9	30	11.4	10.3	+1.1

MAGNETIC OBSERVATIONS AT PILAR, MAY 28–30, 1919.

By F. H. Bigelow.

Table 1 contains for the Pilar Magnetic Observatory, Argentina, the five-minute means of magnetic declination, D, derived from the magnetometer values for every minute from $9^h\ 58^m$ to $16^h\ 32^m$, Greenwich civil mean time May 29, 1919, and of the corresponding magnetograph values on May 28 and 30, all referred to the mean base-line 7° 35′.92. The bracketted quantities indicate that occasionally one (or more) of the single-minute values of the five, from which the mean was to be taken, was missed. At $14^h\ 49^m$, G. M. T., May 30, the base-line was displaced +1′.0 by an earthquake, and the corrected base-line of 7° 36′.92 was used accordingly, to reduce the subsequent readings.

The *geographic coordinates* are: latitude, 31° 40′ S.; longitude, 63° 53′ or $4^h\ 15^m.5$ W. [Besides the magnetic observations complete *meteorological data* for May 28–30, as also *solar-radiation observations* for May 28 and 29, were supplied.—*Ed.*]

TABLE 1.—*Five-minute means of D, and* △*D.*
[D = E 7° 50′ + tabular quantity; N is the mean of May 28 and 30; △D = D (May 29 − N).]

G.M.T.	N	29	△D	G.M.T.	N	29	△D	G.M.T.	N	29	△D
h m	′	′	′	h m	′	′	′	h m	′	′	′
10 00	[7.1]	7.3	[+0.2]	12 10	6.5	6.8	+0.3	14 20	4.9	[4.8]	[−0.1]
05	[7.1]	7.4	[+0.3]	15	6.4	6.7	+0.3	25	4.9	5.0	+0.1
10	[7.0]	7.4	[+0.4]	20	[6.3]	[6.5]	[+0.2]	30	5.0	5.1	+0.1
15	[6.9]	7.4	[+0.5]	25	6.2	6.4	+0.2	35	5.2	5.2	0.0
20	6.9	7.4	+0.5	30	6.2	6.4	+0.2	40	5.2	5.2	0.0
25	6.9	7.4	+0.5	35	6.1	6.2	+0.1	45	5.4	5.4	0.0
30	7.1	7.4	+0.3	40	6.0	6.1	+0.1	50	[5.6]	5.6	[0.0]
35	7.1	7.4	+0.3	45	5.8	6.0	+0.2	55	5.7	5.6	−0.1
40	7.1	7.4	+0.3	50	5.6	5.8	+0.2	15 00	5.8	5.7	−0.1
45	7.2	7.6	+0.4	55	5.6	5.8	+0.2	05	5.8	5.7	−0.1
50	7.2	7.6	+0.4	13 00	5.5	5.7	+0.2	10	5.9	5.8	−0.1
55	7.3	7.6	+0.3	05	5.4	5.7	+0.3	15	6.0	5.8	−0.2
11 00	7.4	7.6	+0.2	10	5.3	5.5	+0.2	20	6.2	5.8	−0.4
05	7.4	7.6	+0.2	15	5.3	5.2	−0.1	25	6.2	5.9	−0.3
10	7.5	7.7	+0.2					30	6.5	6.1	−0.4
15	7.5	7.7	+0.2	20	5.3	5.1	−0.1	35	6.6	6.2	−0.4
20	7.4	7.7	+0.3	25	5.1	5.1	0.0	40	6.7	6.3	−0.4
25	7.3	7.7	+0.4	30	5.0	5.1	+0.1	45	6.8	6.4	−0.4
30	7.2	7.7	+0.5	35	4.9	5.0	+0.1	50	6.9	6.6	−0.3
35	7.1	7.7	+0.6	40	4.9	4.9	0.0	55	7.1	6.7	−0.4
40	7.0	7.6	+0.6	45	4.9	4.9	0.0	16 00	7.2	6.8	−0.4
45	7.0	7.5	+0.5	50	5.0	4.9	−0.1	05	7.3	7.0	−0.3
50	7.0	7.4	+0.4	55	5.0	4.9	−0.1	10	7.4	7.1	−0.3
55	6.9	7.1	+0.2	14 00	5.0	4.9	−0.1	15	7.5	7.2	−0.3
12 00	6.9	7.1	+0.2	05	5.1	4.9	−0.2	20	7.6	7.5	−0.1
05	6.7	6.9	+0.2	10	5.0	4.9	−0.1	25	7.9	7.7	−0.2
				15	[5.0]	4.8	[−0.2]	30	8.0	7.9	−0.1

MAGNETIC OBSERVATIONS AT TORTOSA, MAY 29, 1919.

By Rev. R. Cirera, S. J.

J'ai le plaisir de vous envoyer une copie de deux courbes magnétiques: l'une, le jour de l'éclipse du 29 mai 1919, et l'autre un jour calme (8–9 Mai) du même mois. En outre, je vous remets la Mémoire No. 3, *La Section Magnétique*, quoiqu' elle se trouve sans doute dans votre bibliothéque, afin que vous puissiez plus aisément l'utiliser pour l'étude de nos courbes.

Vous trouverez dans chaque copie les valeurs des lignes de repére de la déclinaison *D*, composante horizontale *H*, et composante verticale *Z*.

J'espère que les copies photographiques de notre station, qui fonctionne avec toute régularité et qui est placée pas loin de la zone de l'éclipse, pourront vous rendre quelque service.

[*Geographic coordinates* of Observatoire de l'Ebro-Roquetas, near Tortosa, Spain, are: latitude, 40° 49′.2 N.; longitude, $0^h\ 02^m$ E. Since the curves do not show anything particularly different from those at other European stations, for which more detailed data are available, it was not deemed necessary to scale the supplied magnetograms.—*Ed.*]

MAGNETIC OBSERVATIONS AT LUKIAPANG, MAY 28–30, 1919.

By Rev. J. de Moidrey, S. J.

[Copies of the magnetograph-curves, *D*, *H*, and *Z*, for the prescribed G. M. T. interval and for the 5 days, May 27-31, 1919, were supplied, together with the requisite information as to times, values of base-lines and scale-values. Table 1 contains the hourly values as furnished, *N* here being the mean of the 4 days, May 27, 28, 30, and 31, instead of simply May 28 and 30. Table 1 also contains the differences, $\triangle D$, $\triangle H$, and $\triangle Z$, as derived by subtracting the value *N* from the corresponding one for May 29, taking west *D* as minus. The *geographic coordinates* are: Latitude, 31° 19′ N.; longitude, 121° 02′ or $8^h\ 04^m.1$ E.—*Ed.*]

Table 1.—*Hourly values of D, H, Z, and differences.*

G.M.T.	D = W 3°10′+		Diff.	$H = 33200\gamma +$		Diff.	$Z = 33800\gamma +$		Diff.	G.M.T.
	N	29	$\triangle D$	*N*	29	$\triangle H$	*N*	29	$\triangle Z$	
h	′	′	′	γ	γ	γ	γ	γ	γ	h
10	8.6	8.1	+0.5	10	15	+5	34	47	+13	10
11	8.8	8.5	+0.3	07	14	+7	33	44	+11	11
12	9.0	9.2	−0.2	12	18	+6	32	42	+10	12
13	9.3	9.1	+0.2	12	18	+6	32	39	+7	13
14	9.5	9.1	+0.4	12	19	+7	31	38	+7	14
15	9.4	8.8	+0.6	11	20	+9	31	34	+3	15
16	9.3	8.8	+0.5	12	17	+5	28	32	+4	16
17	9.1	8.4	+0.7	13	14	+1	27	32	+5	17
18	8.9	8.4	+0.5	14	08	−6	28	32	+4	18

MAGNETIC OBSERVATIONS AT APIA, MAY 29, 1919.

By G. Angenheister, *Observer-in-Charge*.

Tables 1 and 2 contain the five-minute means derived from the single-minute values of D (declination), H (horizontal intensity), and Z (vertical intensity), from $9^h\ 58^m$ to $16^h\ 32^m$, G. M. T., May 29, 1919.

Geographic coordinates of the Samoa Observatory at Apia are: latitude, 13° 48′ S.; longitude, 171° 46′ or $11^h\ 27^m$ W.

[Copies of portions of the magnetograms for May 28, 29, 30 and, and for the interval concerned, were also supplied.—*Ed.*]

Table 1.—*Five-minute means of D, May 29, 1919.*
[D = E 10° + tabular quantity.]

G.M.T.	10^h	11^h	12^h	13^h	14^h	15^h	16^h	G.M.T.
m	′	′	′	′	′	′	′	m
00	8.3	8.4	8.4	8.4	8.6	8.8	8.9	00
05	8.3	8.4	8.4	8.4	8.6	8.8	8.9	05
10	8.3	8.4	8.4	8.4	8.6	8.8	9.0	10
15	8.3	8.4	8.4	8.5	8.6	8.8	9.1	15
20	8.3	8.4	8.4	8.5	8.7	8.8	9.1	20
25	8.3	8.4	8.4	8.5	8.7	8.8	9.1	25
30	8.4	8.4	8.4	8.5	8.7	8.8	9.1	30
35	8.4	8.4	8.4	8.5	8.7	8.9	..	35
40	8.4	8.4	8.4	8.6	8.7	8.9	...	40
45	8.4	8.4	8.4	8.6	8.8	8.9	...	45
50	8.4	8.4	8.4	8.6	8.8	8.9	.	50
55	8.4	8.4	8.4	8.6	8.8	8.9	...	55

Table 2.—*Five-minute means of H and Z, May 29, 1919.*
[H = 35200γ + tab. quant.; Z = 20350γ − tab. quant.]

G.M.T.	10^h		11^h		12^h		13^h		14^h		15^h		16^h	
	H	*Z*	*H*	*Z*	*H*	*Z*	*H*	*Z*	*H*	*Z*	*H*	*Z*	*H*	*Z*
m	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
00	86	40	87	42	89	43	88	46	88	47	90	49	90	50
05	86	40	88	42	89	43	88	46	88	47	90	49	90	50
10	86	40	88	42	89	44	88	46	88	47	90	49	90	50
15	87	40	88	42	89	44	88	46	88	48	90	49	90	50
20	87	41	88	42	89	45	88	46	89	48	90	49	91	50
25	87	41	88	42	89	45	88	46	89	48	90	49	92	51
30	87	41	88	42	88	45	88	46	89	48	90	50	92	51
35	87	41	88	42	88	45	88	47	89	48	90	50	..	..
40	87	41	88	43	88	45	88	47	90	48	90	50	..	..
45	87	41	89	43	88	45	88	47	90	49	90	50	..	..
50	87	41	89	43	88	45	88	47	90	49	90	50	..	..
55	87	42	89	43	88	45	88	47	90	49	90	50	..	..

MAGNETIC OBSERVATIONS AT ANTIPOLO, MAY 29, 1919.

By M. Saderra Maso'.

The values of H (horizontal intensity) and of Z (vertical intensity), given in Table 1, have been corrected for the range in temperature in the magnetograph room. May 29 was one of the quietest days (magnetic character 0). The values of the magnetic elements follow very closely the normal diurnal variation.

Before the prescribed observation-hours the *weather* remained irregularly, cloudy and calm, with lightning in different directions. The *air temperatures* are tabulated for each hour.

The *geographic coordinates* of the Antipolo Magnetic Observatory, Philippines, are: Latitude, 14° 36' N.; longitude, 121° 10' or $8^h\ 04^m.7$ E.; altitude, 215 meters.

Table 1.—*Approximate magnetic values, Antipolo, May 29, 1919.*
[D = E 0° 36'.2 + tabular value; H = 38048γ + tabular value; Z = + 11001γ + tabular value.]

G.M.T.		D	H	Z	Temp.	G.M.T.		D	H	Z	Temp.
h	m	'	γ	γ	°C.	h	m	'	γ	γ	°C.
10	00	+0.6	+2	+11	25.1	13	00	−0.1	−1	0	24.6
	05	+0.6	+2	+11			05	−0.1	−1	−1	
	10	+0.6	+2	+11			10	−0.2	0	−1	
	15	+0.6	+2	+11			15	−0.2	+1	−1	
	20	+0.6	+2	+11			20	−0.2	0	−2	
	25	+0.5	0	+11			25	−0.2	+1	−2	
	30	+0.5	0	+10			30	−0.2	+1	−2	
	35	+0.4	0	+10			35	−0.2	−2	−3	
	40	+0.4	0	+10			40	−0.2	−2	−3	
	45	+0.3	+1	+10			45	−0.2	−1	−4	
	50	+0.2	0	+9			50	−0.2	−1	−4	
	55	+0.2	0	+9			55	−0.2	0	−3	
11	00	+0.0	0	+8	24.8	14	00	−0.1	0	−3	24.4
	05	+0.0	0	+8			05	−0.1	0	−4	
	10	−0.0	+1	+7			10	−0.1	0	−5	
	15	−0.1	+2	+7			15	−0.1	0	−6	
	20	−0.1	+2	+6			20	−0.1	+1	−6	
	25	−0.1	+2	+6			25	−0.1	+1	−6	
	30	−0.2	+1	+7			30	−0.1	+1	−6	
	35	−0.2	+1	+6			35	−0.1	−1	−6	
	40	−0.2	+1	+6			40	−0.1	−1	−6	
	45	−0.2	+1	+6			45	−0.0	0	−7	
	50	−0.1	+1	+5			50	−0.0	0	−7	
	55	−0.1	+1	+5			55	−0.0	0	−7	
12	00	−0.1	+1	+5	24.8	15	00	+0.0	0	−7	24.2
	05	−0.1	+1	+4			05	+0.0	+1	−7	
	10	−0.1	+1	+4			10	+0.0	+1	−8	
	15	−0.1	+2	+3			15	+0.0	+1	−8	
	20	−0.1	+2	+3			20	+0.0	0	−8	
	25	−0.1	−1	+2			25	+0.0	−3	−8	
	30	−0.1	−2	+2			30	+0.0	−2	−9	
	35	−0.1	−2	+1			35	+0.0	−2	−9	
	40	−0.1	−2	+1			40	+0.0	−2	−9	
	45	−0.1	−2	0			45	+0.0	−1	−9	
	50	−0.1	−2	0			50	+0.0	−1	−10	
	55	−0.1	−2	0			55	+0.0	−1	−10	
						16	00	+0.0	−1	−10	24.1

MAGNETIC OBSERVATIONS AT DE BILT, MAY 28–30, 1919.

By E. van Everdingen, *Director*.

According to Dr. Bauer's circular of February 15, 1919, the following is an abstract of the observations at the De Bilt Magnetic Observatory, Holland, from $9^h\ 58^m$ to $16^h\ 32^m$, G. M. T., May 29, 1919. The five-minute means in Table 1 have been derived from the single-minute scalings of the Adie-magnetograms, the curves consisting of a series of points, ¼mm. apart, given every minute by means of a contact-clock (see *Terr. Mag.*, vol. 21, 1916, p. 145). Care was taken that the moment of the contacts was exactly at zero second Greenwich mean time. The value of 1 mm. ordinate was: D: 1′.06; H : 3.33γ; Z: 4.03γ.

Geographic coordinates: Lat., 52° 06′ N.; long., 5° 11′ or $20^m.7$ E.

Table 1.—*Five-minute means of magnetic elements, May 29, 1919.*
[D = W 11° 35′ + tab. quantity; H = 18400γ + tab. quantity; Z = 43000γ + tab. quantity.]

G.M.T.	10^h			11^h			12^h			13^h			14^h			15^h			16^h		
	D	*H*	*Z*	*D*	*H*	*Z*	*D*	*H*	*Z*	*D*	*H*	*Z*	*D*	*H*	*Z*	*D*	*H*	*Z*	*D*	*H*	*Z*
m	′	γ	γ	′	γ	γ	′	γ	γ	′	γ	γ	′	γ	γ	′	γ	γ	′	γ	γ
00	0.3	08	62	3.3	00	58	6.5	07	58	8.7	12	65	9.3	23	71	6.5	39	78	3.4	45	84
05	0.4	07	62	3.6	00	58	6.7	07	57	8.8	13	66	9.5	26	71	6.2	40	79	3.1	44	85
10	0.8	06	62	3.9	02	57	7.0	07	58	8.6	12	65	9.3	27	72	5.8	41	79	2.8	43	86
15	1.1	07	61	4.3	01	57	7.2	08	59	8.5	11	66	8.9	25	72	5.4	42	80	2.5	40	87
20	1.4	06	60	4.5	01	56	7.3	09	59	9.1	15	66	8.7	26	74	5.1	42	80	2.2	38	87
25	1.8	07	59	4.7	02	57	7.8	11	59	9.3	16	66	8.7	30	75	4.8	41	80	2.2	39	89
30	2.0	05	58	4.9	03	57	8.0	10	60	9.4	17	66	8.3	31	75	4.6	41	81	2.0	35	90
35	2.3	04	59	5.3	04	56	8.1	11	61	9.6	19	68	8.1	32	75	4.6	41	82	...	..	..
40	2.5	03	58	5.7	05	56	8.2	11	61	9.6	20	68	7.8	33	77	4.2	42	82	...	..	..
45	2.6	02	58	5.8	05	56	8.0	10	62	9.5	21	68	7.6	35	77	4.0	44	82	...	..	..
50	2.8	01	58	6.2	07	57	8.2	11	63	9.4	20	70	7.5	40	78	4.0	47	82	...	..	..
55	3.1	01	58	6.4	07	57	8.3	11	64	9.3	21	71	7.0	40	78	3.8	48	82	...	..	..

Table 2.—*Declination hourly values and diurnal variation.*
[D = W 11° 20′ + tabular quantity; N = mean of May 28 and 30; *29* = May 29; dD = diurnal variation.]

G.M.T.	*D*		*dD*		G.M.T.	*D*		*dD*		G.M.T.	*D*		*dD*	
	N	29	*N*	29		*N*	29	*N*	29		*N*	29	*N*	29
h	′	′	′	′	h	′	′	′	′	h	′	′	′	′
1	15.0	15.2	+0.2	+0.8	9	11.8	12.0	+3.4	+4.0	17	16.2	15.9	−1.0	+0.1
2	14.6	15.2	+0.6	+0.8	10	14.8	15.3	+0.4	+0.7	18	15.6	15.3	−0.4	+0.7
3	13.8	14.4	+1.4	+1.6	11	17.4	18.3	−2.3	−2.3	19	15.6	15.9	−0.4	+0.1
4	12.2	14.4	+3.0	+1.6	12	20.0	21.5	−4.8	−5.5	20	16.4	15.9	−1.2	+0.1
5	09.4	14.6	+5.8	+1.4	13	22.0	23.7	*−6.8*	−7.7	21	16.4	15.7	−1.2	+0.3
6	09.0	09.1	+6.2	**+6.9**	14	21.3	24.3	−6.1	*−8.3*	22	17.3	15.9	−2.1	+0.1
7	08.4	10.1	**+6.8**	+5.9	15	19.4	21.5	−4.2	−5.5	23	16.8	15.5	−1.6	+0.5
8	09.7	09.8	+5.5	+6.2	16	17.3	18.4	−2.1	−2.4	24	15.4	15.3	−0.2	+0.7

Mean N (May 28 and 30) : 11° 35′.2 W.; hourly range, 13′.6.
Mean *29* (May 29) : 11° 36′.0 W.; hourly range, 15′.2.

[It will be observed that the range of the hourly values was slightly larger on May 29 than for the mean of the two calm days, May 28 and 30.—*Ed.*]

MAGNETIC OBSERVATIONS AT RUDE SKOV, MAY 29, 1919.

By Captain Carl Ryder, *Director.*

[The data supplied for Rude Skov Magnetic Observatory, Copenhagen, Denmark, consisted of values of magnetic declination (D), horizontal intensity (H) and vertical intensity (Z), for every minute from $9^{h}\ 58^{m}$ to $16^{h}\ 32^{m}$, Greenwich civil mean time, May 29, 1919. Tables 1 and 2 contain the derived five-minute means. *Geographic coordinates*: lat., 55° 50′ G. N.; long., 12° 27′.4 or 0^{h} $49^{m}.8$E.—*Ed.*]

Table 1.—*Five-minute means of D, May 29, 1919.*
[D = W 8° + tabular quantity.]

G.M.T.	10^{h}	11^{h}	12^{h}	13^{h}	14^{h}	15^{h}	16^{h}	G.M.T.
m	′	′	′	′	′	′	′	m
00	08.5	11.2	14.4	15.7	14.9	12.8	09.7	00
05	08.6	11.2	14.6	15.7	14.8	12.5	09.4	05
10	08.8	11.4	14.9	15.6	14.7	12.3	09.2	10
15	09.1	11.8	15.1	15.5	14.5	12.1	09.1	15
20	09.4	12.1	15.2	15.5	14.4	11.6	09.0	20
25	09.8	12.4	15.5	15.6	14.2	11.4	08.0	25
30	10.0	12.6	15.7	15.5	13.9	11.3	08.6	30
35	10.4	13.1	15.9	15.4	13.7	11.0	....	35
40	10.5	13.4	15.9	15.4	13.5	10.6	....	40
45	10.6	13.5	15.8	15.3	13.5	10.3	....	45
50	10.8	13.9	15.8	15.2	13.3	10.2	....	50
55	11.1	14.2	15.7	15.1	13.0	10.0	....	55

Table 2.—*Five-minute means of H and Z, May 29, 1919.*
[H = 17100γ + tab. quantity; Z = 44550γ + tab. quantity.]

G.M.T.	10^{h}		11^{h}		12^{h}		13^{h}		14^{h}		15^{h}		16^{h}	
	H	*Z*	*H*	*Z*	*H*	*Z*	*H*	*Z*	*H*	*Z*	*H*	*Z*	*H*	*Z*
m	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
00	39	36	33	37	40	41	46	48	58	57	77	63	85	67
05	39	37	33	37	40	41	46	49	61	59	79	64	85	67
10	38	38	35	39	40	41	45	50	65	60	79	64	83	69
15	39	38	35	39	40	41	45	51	62	60	79	64	80	67
20	39	38	35	38	42	42	51	52	64	58	79	64	79	67
25	39	38	35	38	44	43	52	53	67	61	79	64	80	67
30	37	37	38	39	43	44	52	53	68	60	79	64	78	67
35	35	37	38	39	44	45	55	54	70	60	79	66	..	..
40	35	37	39	41	44	46	55	55	70	61	80	67	..	..
45	33	36	40	42	42	46	56	56	72	62	83	68		..
50	33	37	40	42	44	46	56	56	77	63	86	70	.	..
55	33	37	40	41	44	47	57	56	78	65	87	69	..	..

MAGNETIC OBSERVATIONS AT VALENCIA, MAY 29, 1919.

By L. H. G. Dines, *Superintendent.*

A temporary declinometer was erected in the basement of the Valencia Observatory at Cahirciveen, Ireland, and readings were taken from it every minute from $9^h 58^m$ to $16^h 50^m$, G. M. T., May 29, 1919. [Table 1 contains the five-minute means derived from these observations.] The chronometer used is regularly verified several times per week by a direct time signal from Greenwich, and by allowing for the error at the time, the readings of the declinometer were taken at each exact minute G. M. T. It is not at all likely that there was any systematic error greater than ± 2s.

Eleven readings [determinations] of absolute declination (Table 2) were taken at intervals between 9^h and 17^h in the observatory magnetic hut in the usual manner (i. e. one reading erect, two inverted, one erect), and compared with exactly simultaneous readings of the declinometer.

The declinometer consisted of a telescope, a mirror magnet suspended by silk fiber 27 cm. long and fitted with an oil damper beneath it, and a fixed scale. The scale could be read to within about 2″ of arc. Damping and sensitivity tests were made and the instrument found to work freely and well, and it being heavily damped no difficulty was found in taking accurate instantaneous readings. The apparatus was set up two days previously and the silk suspension was not subsequently disturbed. From 13^h on the 28th onwards the magnet and suspension were practically unaffected by anything more than natural variations in the declination. Two observers took turns in taking the readings, and in order to be sure that no personal error was thereby introduced a systematic comparison for this purpose was made between them before hand, but no measurable difference could be detected then or at any time.

The 11 control observations (Table 2) taken by one observer were compared with simultaneous readings of the declinometer scale, and the mean base value directly obtained. The scale value was then determined by the method of least squares and a value of 0′.459 per 1 mm. on the scale so found. Another determination made from a consideration of the dimension and constants of the apparatus gave a value of 0′.447 per mm. It seemed best to use a mean between the two and accordingly 0′.453 per mm. was employed in the reduction of the scale-readings. There seems no reason to doubt that the differences between individual readings not far separated in respect to time can be relied upon to within about 3″, but this degree of accuracy could not be claimed for the whole range owing to a small uncertainty in the scale value (1 percent or 2 percent perhaps) and changes in temperature rendering small uncertainties in the action of the silk fibres probable.

The observatory is situated about 120 meters from a railway track and passing trains caused some small disturbances, but the trains were few in number and it is not thought that any of the readings were affected to an extent of more than 3″. It should also be stated that very great care was taken to prevent artificial magnetic disturbances in the neighborhood of the declinometer during the time that the observations were in progress.

Geographic coordinates: Latitude, 51° 56′ N; longitude, 10° 15′ or 41^{m} W.

Table 1.—*Five-minute means of D, May 29, 1919.*
[D = W 19° 20′ + tabular quality.]

G.M.T.	10^{h}	11^{h}	12^{h}	13^{h}	14^{h}	15^{h}	16^{h}	G.M.T.
m	′	′	′	′	′	′	′	m
00	4.7	08.4	12.8	16.0	16.6	15.3	13.9	00
05	5.0	08.8	13.2	16.1	16.6	15.2	13.8	05
10	5.3	09.1	13.6	16.1	16.4	15.1	13.7	10
15	5.7	09.4	14.1	16.0	16.2	15.0	13.6	15
20	6.0	09.8	14.3	16.2	16.1	15.0	13.4	20
25	6.3	10.3	14.7	16.5	16.0	14.9	13.3	25
30	6.7	10.5	15.0	16.5	15.9	14.9	13.2	30
35	7.1	10.9	15.3	16.5	15.9	14.8	13.0	35
40	7.4	11.3	15.5	16.6	15.8	14.6	12.7	40
45	7.8	11.7	15.6	16.6	15.8	14.4	12.5	45
50	8.0	12.1	15.7	16.6	15.7	14.3	12.6	50
55	8.3	12.4	15.9	16.6	15.4	14.1	....	55

Table 2.—*Hut Values of D, May 29, 1919.*
[D = W 19° 20′ + tabular value.]

G.M.T.	D	G.M.T.	D	G.M.T.	D	G.M.T.	D
h m	′	h m	′	h m	′	h m	′
9 26	3.2	10 39	07.5	13 35	16.2	16 14	13.3
9 54	4.2	12 30	14.5	13 52	16.4	16 36	12.3
10 18	5.3	12 44	16.3	15 58	14.2		

[*The reports on the magnetic observations made in connection with the eclipse of May 29, 1919, will be continued in the December issue.*]

PRELIMINARY RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE FROM ST. HELENA TO CAPE TOWN AND THENCE TO COLOMBO, CEYLON, APRIL TO JUNE, 1920.[1]

By J. P. Ault, *Commanding the Carnegie.*

(*Observers:* J. P. Ault, H. F. Johnston, R. R. Mills, H. R. Grummann, and R. Pemberton.)

Date	Latitude	Long. East of Gr.	Carnegie Values			Chart Differences[2]					
						Decl'n and Incl'n			Hor. Int.[3]		
			Decl'n	Incl'n	Hor. Int.	Brit.	Ger.	U.S.	Brit.	Ger.	U.S.
1920	° ′	° ′	°	°	c.g.s.	°	°	°			
Apr. 4	17 06 S	352 18	25.0W	......	.....	0.3W	0.4W	0.1E	....	....	....
4	17 37 S	351 33	......	37.2S	.226	2.5S	10.1S	1.0S	−12	−2	−3
4	17 48 S	351 22	25.3W	......	.....	0.5W	0.5W	0.0	....	....	....
4	17 56 S	351 14	25.1W	......	.....	0.3W	0.3W	0.2E	....	....	....
5	19 15 S	349 45	25.6W	......	.....	0.5W	0.4W	0.1W	....	....	....
5	19 46 S	349 14	......	37.1S	.221	1.9S	9.5S	0.5S	−12	−4	−4
5	20 04 S	348 58	25.9W	......	.....	0.8W	0.6W	0.3W	....	....	....
6	21 24 S	347 46	25.8W	......	.....	0.7W	0.5W	0.4W	....	....	....
6	21 29 S	347 40	26.4W	......	.....	1.3W	1.1W	1.0W	....	....	....
6	21 44 S	347 28	......	37.8S	.218	2.0S	9.6S	1.1S	−10	−4	−3
6	21 53 S	347 20	25.6W	......	.....	0.5W	0.3W	0.2W	....	....	....
7	22 34 S	346 44	25.7W	......	.....	0.7W	0.4W	0.4W	....	....	....
7	22 48 S	346 35	......	38.3S	.216	2.3S	9.4S	1.3S	−11	−4	−2
7	22 49 S	346 34	25.3W	......	.....	0.3W	0.0	0.0	....	....	....
8	23 43 S	346 01	26.3W	......	.....	1.3W	1.1W	1.1W	....	....	....
8	24 33 S	345 40	......	38.9S	.214	1.7S	8.2S	1.1S	−9	−5	0
9	24 49 S	345 40	25.5W	......	.....	0.6W	0.3W	0.4W	....	....	....
9	25 41 S	345 24	25.7W	......	.....	0.8W	0.6W	0.7W	....	....	....
10	26 30 S	344 42	25.9W	......	.....	1.3W	1.0W	1.1W	....	....	....
10	26 55 S	344 11	......	39.5S	.212	1.3S	7.6S	0.9S	−8	−6	+1
10	27 02 S	344 04	25.4W	......	.....	1.0W	0.6W	0.8W	....	....	....
11	29 30 S	342 38	......	40.6S	.209	1.0S	7.0S	0.7S	−9	−9	0
11	29 38 S	342 38	25.2W	......	.....	1.5W	1.4W	1.3W	....	....	....
11	29 51 S	342 38	25.1W	......	.....	1.5W	1.4W	1.3W	....	....	....
12	30 40 S	342 37	24.8W	......	.....	1.3W	1.2W	1.1W	....	....	....
12	31 16 S	342 42	......	41.7S	.207	0.7S	6.5S	0.6S	−10	−10	−1
12	31 24 S	342 46	25.0W	......	.....	1.5W	1.4W	1.2W	....	....	....
12	31 33 S	342 52	25.1W	......	.....	1.6W	1.5W	1.4W	....	....	....
13	33 02 S	343 49	24.8W	......	.....	1.2W	1.1W	1.0W	....	....	....
13	33 50 S	344 22	......	44.7S	.203	0.9S	5.7S	1.2S	−11	−12	−2
13	33 56 S	344 26	25.0W	......	.....	1.3W	1.3W	1.1W	....	....	....
13	34 04 S	344 32	24.9W	......	.....	1.2W	1.2W	1.0W	....	....	....

[1]For previous table, see *Terr. Mag.*, vol. 25, p. 49.

[2]Charts used for comparison: U. S. Hydrographic Office Charts Nos. 1700, 1701 and 2406 for 1920; British Admiralty Charts No. 3775 for 1917, 3598 and 3603 for 1907; Reichs-Marine-Amt Charts Tit. XIV, No. 2 for 1910; Tit. XIV, Nos. 2a and 2b for 1905. The chart differences are obtained by subtracting chart values, derived as explained in previous sentence, from the observed *Carnegie* values. The letter E signifies that the chart value for east declination is smaller, or the chart value for west declination larger, than the *Carnegie* value; W signifies the reverse. The letter N signifies that the derived chart value for northerly inclination is smaller, or for southerly inclination larger, than the *Carnegie* value; S signifies the reverse. The plus sign signifies that the derived chart value for horizontal intensity is smaller than the *Carnegie* value, the minus sign meaning, of course, the reverse. Secular corrections have been applied to declinations only.

[3]Expressed in units of third decimal C. G. S.

Date		Latitude	Long. East of Gr.	Carnegie Values			Chart Differences[2]					
							Decl'n and Incl'n			Hor. Int.[3]		
				Decl'n	Incl'n	Hor. Int.	Brit.	Ger.	U.S.	Brit.	Ger.	U.S.
1920		° ′	° ′	°	°	c.g.s.	°	°	°			
Apr.	14	35 51 S	345 59	25.1W	......	.....	1.1W	1.2W	1.0W	.....	.....	.....
	14	36 06 S	346 44	......	47.2S	.200	0.7S	4.9S	0.8S	−12	−12	−2
	14	36 12 S	346 55	25.4W	......	.....	1.2W	1.2W	1.1W	.....	.....	.....
	15	36 23 S	348 44	26.3W	......	.....	1.3W	1.4W	1.3W	.....	.....	.....
	15	36 25 S	349 19	......	49.1S	.195	1.1S	5.1S	0.8S	−15	−15	−4
	15	36 28 S	349 37	26.5W	......	.....	1.2W	1.2W	1.3W	.....	.....	.....
	16	36 55 S	352 13	27.2W	......	.....	1.1W	0.7W	1.1W	.....	.....	.....
	16	37 09 S	353 41	......	51.6S	.192	0.8S	4.6S	0.5S	−15	−15	−3
	16	37 12 S	354 00	27.8W	......	.....	1.2W	0.8W	1.2W	.....	.....	.....
	17	37 26 S	357 24	28.4W	......	.....	1.1W	0.6W	0.9W	.....	.....	.....
	17	37 26 S	358 26	......	54.6S	.184	1.3S	4.4S	1.2S	−18	−18	−5
	17	37 26 S	358 41	28.5W	......	.....	0.9W	0.1W	0.6W	.....	.....	.....
	18	37 01 S	3 02	......	55.9S	.181	0.9S	3.7S	0.5S	−18	−18	−4
	18	36 57 S	3 24	29.3W	......	.....	1.2W	0.4W	0.7W	.....	.....	.....
	19	36 26 S	5 48	28.7W	......	.....	0.5W	0.2E	0.0	.....	.....	.....
	19	35 58 S	6 11	......	57.8S	.176	1.5S	4.4S	1.4S	−20	−21	−7
	20	37 21 S	7 16	29.3W	......	.....	1.1W	0.2W	0.4W	.....	.....	.....
	20	37 36 S	7 59	......	59.2S	.173	1.5S	4.2S	1.5S	−20	−22	−7
	20	37 38 S	8 07	29.0W	......	.....	0.8W	0.0	0.0	.....	.....	.....
	21	37 34 S	10 01	28.7W	......	.....	0.6W	0.2E	0.2E	.....	.....	.....
	21	37 29 S	10 59	......	60.5S	.169	1.7S	4.3S	1.5S	−21	−23	−7
	21	37 29 S	11 10	29.0W	......	.....	1.0W	0.1W	0.3W	.....	.....	.....
	22	36 56 S	12 34	28.3W	......	.....	0.5W	0.5E	0.1E	.....	.....	.....
	22	36 35 S	13 11	......	60.6S	.168	1.2S	3.9S	1.0S	−20	−22	−6
	22	36 30 S	13 19	27.8W	......	.....	0.1W	0.9E	0.5E	.....	.....	.....
	23	35 37 S	15 14	25.9W	......	.....	1.3E	2.5E	1.8E	.....	.....	.....
	23	35 15 S	16 14	......	61.3S	.166	1.5S	3.8S	1.0S	−21	−22	−5
	23	35 10 S	16 26	26.9W	......	.....	0.0	1.3E	0.5E	.....	.....	.....

NOTES ON TRIP FROM ST. HELENA TO CAPE TOWN.

We sailed from St. Helena at 3 P. M., April 3, and after three days of sailing in the southeast trade winds we entered the region of variable winds and calms on April 6. Considerable lightning accompanied by heavy thunder was noted during some heavy squalls in the middle of the South Atlantic Ocean, far from land. By April 11 we had crossed this region of variable winds and had picked up the westerly winds. A moderate to fresh gale blew from the northwest, shifting to southwest, during April 13 and 14.

On April 15 it was planned to make a brief stop at Tristan Island, but, unfortunately, the wind hauled more to the southward and we were unable to make the island. It was plainly visible at a distance of 50 miles on the morning of April 15, rising out of the sea an almost perfect cone.

For four days after sighting Tristan we averaged over 210 miles per day. The usual cycle of atmospheric pressure-changes, with their corresponding changes in the wind for these regions, were experienced. With high pressure northerly winds blow, shifting to northwest and west as the pressure decreases. The more rapid the decrease in pressure the stronger the wind blows. At the lowest point the wind shifts to the southwest and blows hard if the pressure increases rapidly, shifting to south and southeast as the pressure rises, finally jumping to northeast as the highest point is reached. These heavy westerly winds were followed by light southerly to northerly winds during April 18 to 22, shifting to northwest on April 23 and blowing stronger.

We arrived at Cape Town on April 24 after 21 days at sea. The average daily run was 152 miles. Declination observations were made daily and the usual program of magnetic and electric work was carried out.

Date	Latitude	Long. East of Gr.	Carnegie Values			Chart Differences[2]					
						Decl'n and Incl'n			Hor. Int.		
			Decl'n	Incl'n	Hor. Int.	Brit.	Ger.	U.S.	Brit.	Ger.	U.S.
1920	° ′	° ′	°	°	c.g.s.	°	°	°			
May 21	35 18 S	17 53	26.2W	......	.....	0.4E	1.8E	1.0E	.....	.....	.....
21	35 25 S	17 53	26.4W	......	.....	0.3E	1.7E	0.9E	.....	.....	.....
21	36 15 S	17 50	......	62.1S	.163	1.8S	3.6S	1.0S	−21	−24	−4
21	36 23 S	17 50	26.6W	......	.....	0.3E	2.0E	1.0E	.....	.....	.....
22	37 48 S	18 40	26.7W	......	.....	0.5E	2.2E	1.0E	.....	.....	.....
22	38 44 S	18 54	......	63.2S	.158	2.2S	3.6S	0.9S	−24	−26	−6
23	39 40 S	21 29	26.8W	......	.....	0.6E	2.6E	0.9E	.....	.....	.....
23	39 39 S	22 34	......	64.3S	.157	2.5S	3.5S	0.4S	−21	−23	−2
24	39 39 S	24 47	25.1W	......	.....	1.7E	4.1E	1.9E	.....	.....	.....
24	39 42 S	25 34	......	64.6S	.156	2.3S	3.2S	0.3S	−21	−23	−1
24	39 41 S	25 42	25.9W	......	.....	0.8E	3.4E	0.9E	.....	.....	.....
25	39 23 S	28 22	25.0W	......	.....	1.0E	4.0E	1.0E	.....	.....	.....
25	39 19 S	29 24	......	66.4S	.147	3.5S	4.3S	1.8S	−27	−31	−7
25	39 18 S	29 34	25.7W	......	.....	0.1E	3.2E	0.1E	.....	.....	.....
26	38 42 S	31 49	22.7W	......	.....	2.3E	5.6E	2.5E	.....	.....	.....
26	38 18 S	32 29	......	65.3S	.151	2.2S	2.9S	0.8S	−22	−27	−1
27	36 42 S	34 33	22.2W	......	.....	0.8E	4.2E	1.2E	.....	.....	.....
27	36 14 S	35 09	......	65.6S	.152	2.7S	3.3S	1.5S	−22	−29	−3
27	36 07 S	35 18	20.6W	......	.....	1.9E	5.3E	2.2E	.....	.....	.....
28	35 00 S	37 14	20.1W	......	.....	1.0E	4.6E	1.4E	.....	.....	.....
28	34 37 S	38 04	......	65.0S	.154	2.3S	2.8S	1.4S	−22	−30	−5
28	34 32 S	38 20	19.8W	......	.....	0.7E	4.2E	1.0E	.....	.....	.....
29	33 50 S	40 32	19.1W	......	.....	0.4E	3.7E	0.5E	.....	.....	.....
29	33 42 S	41 03	......	64.5S	.157	1.9S	2.3S	1.2S	−21	−29	−8
29	33 39 S	41 15	18.8W	......	.....	0.3E	3.6E	0.4E	.....	.....	.....
30	33 08 S	43 28	19.0W	......	.....	0.8W	2.9E	0.6W	.....	.....	.....
30	33 14 S	44 28	......	64.1S	.161	1.3S	1.8S	1.1S	−19	−27	−6
30	33 16 S	44 44	18.0W	......	.....	0.1E	3.9E	0.5E	.....	.....	.....

Date	Latitude	Long. East of Gr.	Carnegie Values			Chart Differences[2]					
			Decl'n	Incl'n	Hor. Int.	Decl'n and Incl'n			Hor. Int.[3]		
						Brit.	Ger.	U.S.	Brit.	Ger.	U.S.
1920	° ′	° ′	°	°	c.g.s.	°	°	°			
May 31	34 46 S	47 04	19.7W	......	.....	0.7W	3.5E	0.2W	.....	.....	.....
31	34 55 S	47 18	......	64.6S	.160	1.1S	1.4S	1.0S	−17	−26	−4
31	34 50 S	47 17	19.6W	......	.....	0.6W	3.6E	0.1W	.....	.....	.....
June 1	34 30 S	47 23	19.3W	......	.....	0.3W	3.5E	0.0	.....	.....	.....
2	32 59 S	48 13	17.9W	......	.....	0.1W	3.3E	0.0	.....	.....	.....
2	32 20 S	48 51	......	63.6S	.166	1.0S	1.2S	1.0S	−16	−24	−6
2	32 10 S	49 06	17.6W	......	.....	0.4W	2.9E	0.4W	.....	.....	.....
3	31 29 S	51 29	17.3W	......	.....	0.8W	2.5E	0.6W	.....	.....	.....
3	31 18 S	52 37	......	62.6S	.175	0.2S	0.6S	0.5S	−12	−19	−5
3	31 16 S	52 52	17.3W	......	.....	0.7W	2.3E	0.6W	.....	.....	.....
4	30 46 S	55 34	17.5W	......	.....	0.8W	1.7E	0.8W	.....	.....	.....
4	30 33 S	56 49	......	60.9S	.185	1.4N	1.1N	0.8N	−5	−13	0
4	30 31 S	57 08	18.4W	......	.....	1.6W	0.1E	1.6W	.....	.....	.....
4	30 27 S	57 17	18.1W	......	.....	1.3W	0.4E	1.3W	.....	.....	.....
5	30 11 S	60 08	18.7W	......	.....	1.4W	0.6W	1.4W	.....	.....	.....
5	29 52 S	61 10	......	60.9S	.190	1.0N	0.8N	0.5N	−4	−13	−1
5	29 43 S	61 20	19.0W	......	.....	1.7W	1.6W	1.9W	.....	.....	.....
6	28 23 S	63 00	18.0W	......	.....	1.4W	1.4W	1.5W	.....	.....	.....
6	27 48 S	63 47	......	59.4S	.201	1.8N	1.3N	1.0N	0	−12	+11
6	27 37 S	63 57	18.0W	......	.....	1.8W	2.5W	1.7W	.....	.....	.....
7	26 22 S	65 09	17.1W	......	.....	1.6W	2.7W	1.4W	.....	.....	.....
7	25 51 S	65 32	......	58.0S	.211	2.0N	1.4N	1.2N	−1	−11	+2
7	25 37 S	65 36	16.7W	......	.....	1.6W	3.2W	1.6W	.....	.....	.....
8	24 28 S	65 55	15.6W	......	.....	1.2W	2.9W	1.5W	.....	.....	.....
8	23 34 S	66 06	......	55.8S	.223	2.0N	1.7N	1.4N	+2	−7	+3
8	23 16 S	66 07	15.0W	......	.....	1.2W	3.5W	1.7W	.....	.....	.....
9	21 30 S	65 59	13.4W	......	.....	1.1W	3.4W	1.6W	.....	.....	.....
9	20 28 S	65 52	......	53.3S	.235	0.9N	1.3N	0.4N	−2	−8	0
9	20 19 S	65 50	12.6W	......	.....	1.0W	3.8W	1.6W	.....	.....	.....
10	18 24 S	65 36	10.5W	......	.....	0.2W	3.3W	0.5W	.....	.....	.....
10	17 24 S	65 24	......	49.1S	.252	1.7N	2.0N	1.2N	+2	−9	−2
10	17 07 S	65 22	10.3W	......	.....	0.8W	4.0W	1.0W	.....	.....	.....
11	15 10 S	65 08	8.8W	......	.....	0.3W	3.2W	0.7W	.....	.....	.....
11	14 03 S	65 01	......	44.5S	.271	1.4N	2.3N	1.8N	+1	−7	+1
11	13 39 S	64 58	8.1W	......	.....	0.5W	2.9W	0.9W	.....	.....	.....
12	11 25 S	64 39	6.9W	......	.....	0.5W	2.2W	1.1W	.....	.....	.....
12	10 20 S	64 29	......	38.7S	.293	1.8N	2.3N	1.3N	+3	+1	+4
12	9 59 S	64 26	6.2W	......	.....	0.4W	1.7W	0.9W	.....	.....	.....
13	7 57 S	64 12	5.3W	......	.....	0.3W	1.2W	0.7W	.....	.....	.....
13	7 49 S	64 11	5.2W	......	.....	0.3W	1.2W	0.7W	.....	.....	.....
13	7 06 S	64 02	......	33.0S	.310	2.4N	1.9N	1.8N	+3	+3	+3
13	6 50 S	63 56	5.0W	......	.....	0.5W	1.1W	0.8W	.....	.....	.....
14	5 34 S	63 34	4.2W	......	.....	0.2W	0.7W	0.4W	.....	.....	.....
14	4 54 S	63 29	......	28.2S	.322	2.7N	2.4N	2.6N	+2	+6	+5
14	4 42 S	63 30	4.2W	......	.....	0.4W	0.8W	0.6W	.....	.....	.....
15	3 35 S	63 33	3.7W	......	.....	0.1W	0.4W	0.3W	.....	.....	.....
15	3 04 S	63 32	......	24.6S	.330	3.6N	2.3N	2.6N	+3	+7	+5
15	2 58 S	63 29	3.6W	......	.....	0.2W	0.4W	0.4W	.....	.....	.....
16	2 30 S	63 19	3.5W	......	.....	0.3W	0.5W	0.5W	.....	.....	.....
16	1 50 S	63 09	......	21.8S	.336	3.8N	2.2N	3.2N	+1	+8	+6
16	1 36 S	63 06	3.0W	......	.....	0.1W	0.2W	0.3W	.....	.....	.....
17	0 32 S	62 57	2.8W	......	.....	0.2W	0.1W	0.3W	.....	.....	.....

Date	Latitude	Long. East of Gr.	Carnegie Values			Chart Differences[2]					
						Decl'n and Incl'n			Hor. Int.[3]		
			Decl'n	Incl'n	Hor. Int.	Brit.	Ger.	U.S.	Brit.	Ger.	U.S.
1920	° ′	° ′	°	°	c.g.s.	°	°	°			
June 17	0 08 N	62 55	......	17 5S	.344	5.1N	2.5N	3.3N	+2	+11	+4
17	0 23 N	62 54	2.6W	......	.....	0.3W	0.1W	0.3W	.....	.....	.....
18	1 30 N	62 43	2.4W	......	.....	0.4W	0.0	0.4W	.....	.....	.....
18	2 07 N	62 31	......	13.2S	.352	4.9N	3.7N	2.8N	+2	+12	+4
18	2 23 N	62 25	2.2W	......	.....	0.4W	0.1W	0.4W	.....	.....	.....
19	3 28 N	61 55	1.9W	......	.....	0.5W	0.0	0.4W	.....	.....	.....
19	4 06 N	61 37	......	8.9S	.356	4.5N	3.4N	2.5N	+2	+11	+4
19	4 22 N	61 29	1.6W	......	.....	0.5W	0 0	0.3W	.....	.....	.....
20	5 45 N	60 54	1.0W	......	.....	0.2W	0.4E	0.1W	.....	.....	.....
20	6 34 N	60 37	......	3.1S	.362	4.6N	3.9N	2.0N	+4	+12	+6
20	6 57 N	60 26	1.1W	......	.....	0.6W	0.0	0.4W	.....	.....	.....
21	8 32 N	59 43	0.6W	......	.....	0.4W	0.2E	0.2W	.....	.....	.....
21	9 43 N	59 20	......	4.0N	.365	3.0N	4.7N	1.5N	+3	+9	+5
21	10 02 N	59 16	0.3W	......	.....	0.5W	0.2E	0.2W	.....	.....	.....
21	10 18 N	59 14	0.2W	......	.....	0.4W	0.2E	0 2W	.....	.....	.....
22	12 10 N	58 54	0.1E	......	.....	0.4W	0.1E	0.1W	.....	.....	.....
22	12 24 N	58 52	0.1E	......	.....	0.5W	0.1E	0.2W	.....	.....	.....
22	12 52 N	59 18	0.3E	......	.....	0.3W	0.2E	0.0	.....	.....	.....
22	13 03 N	59 32	......	11.8N	.365	4.0N	4.8N	0.8N	+1	+4	+3
22	13 20 N	59 56	0.2E	......	.....	0.4W	0.1E	0.1W	.....	.....	.....
23	12 41 N	61 58	0.2W	......	.....	0.3W	0.1E	0.3W	.....	.....	.....
23	12 18 N	63 10	......	10.5N	.368	3.7N	3.7N	1.0N	0	+5	+2
23	12 07 N	63 35	0.4W	......	.....	0.2W	0.1E	0.2W	.....	.....	.....
24	11 25 N	65 12	0.8W	......	.....	0.2W	0.1W	0.3W	.....	.....	.....
24	10 55 N	66 20	......	7.4N	.375	3.8N	4.3N	1.4N	+5	+10	+5
24	10 41 N	66 46	1.2W	......	.....	0.3W	0.4W	0.4W	.....	.....	.....
25	9 56 N	68 23	1.4W	......	.....	0.1W	0.3W	0.2W	.....	.....	.....
25	9 34 N	69 14	......	3.8N	.376	1.7N	3.4N	0.6N	+5	+10	+4
25	9 29 N	69 27	1.8W	......	.....	0.2W	0.6W	0.4W	.....	.....	.....
26	8 48 N	71 09	2.0W	......	.....	0.1W	0.7W	0.3W	.....	.....	.....
26	8 35 N	71 50	......	1.4N	.378	1.4N	2.4N	0.8N	+6	+11	+5
26	8 31 N	72 02	2.3W	......	.....	0.2W	0.9W	0.5W	.....	.....	.....
27	8 09 N	73 35	2.4W	......	.....	0.0	0.9W	0.4W	.....	.....	.....
27	8 03 N	74 03	......	0.0	.379	1.4N	2.2N	0.0	+5	+11	+4
28	7 46 N	75 08	2.6W	......	.....	0.0	1.0W	0.3W	.....	.....	.....
28	7 38 N	75 50	......	0.9S	.382	1.9N	2.3N	1.5N	+7	+13	+5
28	7 37 N	76 11	2.2W	......	.....	0.5E	0.6W	0.1E	.....	.....	.....
29	7 30 N	78 06	2.2W	......	.....	0.7E	0.5W	0.1E	.....	.....	.....
29	7 17 N	79 03	......	1.9S	.385	0.9N	1.8N	1.6N	+6	+13	+5

Notes on Trip from Cape Town to Colombo.

At 3 P. M., May 20, 1920, the *Carnegie* left the dock at Cape Town and proceeded to sea under tow, the departure having been delayed a few days by matters relating to the crew. The Cape Town harbor authorities gave the *Carnegie* every consideration in the way of free dockage, free pilotage, and free towboat service, a courtesy very much appreciated. After they had towed the vessel well out to sea we started our own engine and ran until after midnight, when a breeze sprang up from the northwest and the *Carnegie* was on her way to Colombo.

On May 22 a fresh gale sprang up from the southwestward and it became necessary to keep the vessel off to the eastward. On May 23 the gale moderated but the wind shifted to the southward, thus preventing our making as far south as had been planned. On May 24 another gale commenced from the northward and continued to blow throughout May 25 and 26. Fortunately its direction was such that the vessel could keep on her course without too much strain and so good progress was made. *Declination observations were made daily and usually twice daily in regions where none had been secured during the 1911 cruise.* On May 30 a head wind was encountered and the vessel was driven to the southeastward out of her course for one day, the only head wind encountered during the trip. This head wind was followed by a calm which lasted 10 hours, the wind shifting from northeast to southeast, dying out, and again springing up from the same quarter. Another gale developed on June 2 and continued on June 3, 4, and 5, the vessel making over 200 miles daily—running before the gale.

June 5 and 6 saw a gradual change of course leading up into the Indian Ocean. The region of the westerlies was gradually left behind and on June 8, after three hours of calm, the southeast trade wind was picked up. For one week excellent weather prevailed and the vessel averaged over 180 miles per day while crossing the southeast trade wind belt. The southwest monsoon was encountered on June 15, after about four hours of calms. For over four days this monsoon was very light but on June 20 it began to blow more strongly, and finally on June 22 it developed into a gale and blew for over two days. *During this gale the agonic line was crossed twice, as also the Carnegie's track of 1911 in the Arabian Sea.* Owing to the strength of the monsoon and its tendency to blow more from the southward than from the westward, it was decided not to go farther north into the Arabian Sea. To make sure of weathering the Laccadive Islands the course was shaped for Colombo on June 22, after being certain that we were well to the northward of the agonic line. At midnight on June 26 we sighted the light on Minikoi Island, as expected. Eastward of Minikoi the southwest monsoon was very light, so that we did not reach Colombo until $10^h\ 30^m$ A. M., June 30, after having been hove to all night.

Declination observations were made twice daily on 29 days, once daily on only 6 days, three times daily on three days, and four times on one day, when crossing the agonic line. The chart errors in declination for the southern part of the Indian Ocean averaged over 1°, sometimes reaching 2.°5. In the northern part of the Indian Ocean they were less than 0.°5. *Inclination and horizontal intensity observations* were made daily with the exception of one day, when the vessel had been becalmed.

The total distance covered from Cape Town to Colombo was 6,665 nautical miles, giving an average of 163.4 miles for 40.8 days of the trip. This is a very high average for the *Carnegie* for a trip of over 40 days. Rain or precipitation fell on 29 out of 41 days.

UEBER DIE BESTIMMUNG DER ERDMAGNETISCHEN AKTIVITAET.

VON ADOLF SCHMIDT *in Potsdam.*

Durch die auf der Innsbrucker Conferenz (1905) beschlossene Einführung der internationalen Charakterzahlen[1] ist eine in praktischer Hinsicht recht befriedigende Lösung der Aufgabe erzielt worden, die von Tag zu Tag wechselnde Lebhaftigkeit der erdmagnetischen Vorgänge zahlenmässig zu kennzeichnen. Die Einfachheit und Anschaulichkeit des Verfahrens hat fast alle Magnetwarten der Erde zur Mitwirkung veranlasst (nur Uccle und Tokio haben sich dauernd ausgeschlossen), und die mustergültige Verarbeitung und Veröffentlichung des einlaufenden Stoffs durch das Niederländische Meteorologische Institut macht die Ergebnisse der wissenschaftlichen Verwertung schnell und allseitig zugänglich. Der einzige, natürlich von vornherein bewusst in den Kauf genommene Mangel des Verfahrens liegt in dem subjektiven Charakter der Stufenschätzung an den einzelnen Observatorien. Er verliert indessen durch die grosse Zahl der im Schlusswert vereinigten, von einander ganz unabhängigen Einzelwerte sehr an Bedeutung und ist eine notwendige Folge der Unbestimmtheit des Begriffs der Aktivität. Nur indem man diesen scharf bestimmt, was natürlich seinerseits eine gewisse Willkür einführt und die Gefahr eines systematischen Mangels durch einseitige Betonung einzelner Umstände mit sich bringt, kann man zu objektiv festgelegten Zahlen gelangen. Ob diesen aber eine wertvolle sachliche Bedeutung zukommt, bleibt eine Frage für sich, die erst nachträglich durch die mit ihrer Verwendung erzielten Erfolge zu entscheiden ist.

Der Versuch einer solchen Definition der Aktivität, den Fr. Bidlingmaier gemacht hat,[2] benutzt das in formaler Beziehung nächstliegende und zweckmässigste Ausdrucksmittel, den quadratischen Durchschnitt der Abweichungen von einem gewissen Normalverlauf.[3] Sein hauptsächlicher Mangel liegt in der Willkür, die

[1] Die internationalen erdmagnetischen Charakterzahlen, *Meteorologische Zeitschrift*, 1916, S. 481–492.

[2] *Veröffentlichungen des Kaiserlichen Observatoriums in Wilhelmshaven.* Ergebnisse der magnetischen Beobachtungen im Jahre 1911, mit besonderen Untersuchungen über die erdmagnetische Aktivität. Berlin, 1913.

[3] *K. Birkeland* nimmt statt dessen den Durchschnitt der absoluten Beträge der Abweichungen, teilweise unter Trennung der positiven von den negativen. Seine Zahlen der so von ihm definierten "Storminess", die er in grosser Ausführlichkeit nach den Beobachtungen seiner 4 Polarlichtstationen mitteilt und bearbeitet, verhalten sich also zu denen von Bidlingmaier wie der sogenannte durchschnittliche zum mittleren Fehler. Vgl. *The Norwegian Aurora Polaris Expedition*, 1902–1903. Vol. 1, Section II, Ch. III (p. 451–552). Christiania, 1913.

bei der Wahl dieses normalen Verlaufs besteht; er lässt sich dadurch mildern, dass man verschiedene Möglichkeiten neben einander berücksichtigt, also mehrere Zahlen (z. B. A^x_h, A^h_d, A^d_a nach Bidlingmaiers Bezeichnung) gleichzeitig zur Angabe der Aktivität verwendet. Dadurch wird zugleich ein weiterer Mangel abgeschwächt, der Umstand nämlich, dass die durch häufigen, schnellen Wechsel der Bewegungsrichtung bedingte Unruhe des Verlaufs, an die man eigentlich bei dem Begriffe der Aktivität zuerst denkt, keinen Einfluss auf jenen Mittelwert übt und daher in ihm gar nicht unmittelbar zum Ausdruck kommt. Er gelangt nur mittelbar etwas zur Geltung und zwar um so mehr, je kleiner die einzelnen Zeitabschnitte sind, deren Mittelwerte den als normal betrachteten Verlauf definieren, am meisten also bei A^x_h, und noch mehr, wenn man zu Bruchteilen der Stunde überginge.

Trotz dieser Mängel, die mehr oder weniger auch bei jeder anderen Definition der Aktivität zu befürchten wären, verdient Bidlingmaiers Vorschlag ernste Beachtung, und es ist erfreulich, dass er sie auch gefunden hat. An mehreren Observatorien, von denen allerdings erst eins seine Ergebnisse veröffentlicht hat,[4] sind die Beobachtungen eines vollen Jahres (1915) danach bearbeitet worden. Ausserdem liegt eine sehr eingehende Untersuchung von Chree[5] und eine kürzere Mitteilung von Hazard[6] über einen einzelnen Punkt vor, nämlich über das Näherungsverfahren, das Bidlingmaier für die Bestimmung der Stundenaktivität A^x_h ausgearbeitet hat.

Ist y der zu irgend einem Augenblick gehörige Wert eines Elements, y_m sein Stundenmittel, was durch $M(y) = y_m$ ausgedrückt werden möge, setzt man ferner $y - y_m = \eta$, wonach $M(\eta) = 0$ gilt, so ist—abgesehen von dem Faktor $1 : 8\pi$, den Bidlingmaier aus theoretischen Gründen hinzufügt—die Aktivität A^x_h der betreffenden Stunde durch den Mittelwert $M(\eta^2)$ gegeben. Dieser wird streng durch ein Integral definiert; statt dessen kann er näherungsweise aus einer hinreichenden Anzahl äquidistanter Werte von y (Bidlingmaier nimmt 10, Chree 12) abgeleitet werden, was höchstens in vereinzelten Ausnahmefällen zu merklichen Fehlern führt. Da aber auch dieses Verfahren für die praktische Anwendung, weil es sich um sehr zahlreiche Einzelwerte handelt, noch viel zu umständlich und zeitraubend wäre, so führt

[4] *Ergebnisse der magnetischen Beobachtungen in Potsdam und Seddin im Jahre 1915*. S. 29–36 u. (28)–(32). (Weiterhin kurz als *Erg.* 1915 zitiert.) Vgl. dazu eine Berichtigung in *Erg.* 1917, S. 12.

[5] Magnetic activity and hourly range, *Terr. Mag. and Atm. El.*, vol. 22, 1917, S. 57–83.

[6] Activity of the Earth's magnetism, *ibid.* S. 84–86.

Bidlingmaier eine weitere Vereinfachung ein, die einen der Hauptpunkte seines Vorschlags ausmacht, und auf die sich eben die erwähnten Untersuchungen von Chree und Hazard ausschliesslich beziehen. Er misst die stündliche Schwankung $2a$ (oder R, wie Chree schreibt), d. h. den Unterschied des höchsten und des niedrigsten Wertes von y während der Stunde und betrachtet $M(\eta^2)$ als Funktion davon. Diese Funktion bestimmt er empirisch durch wirkliche Ausmessung und Berechnung von $2a$ und $M(\eta^2)$ an einer grösseren Anzahl planmässig ausgewählter Stundenabschnitte. Indem er dann bei der praktischen Anwendung einfach den so ein für alle Mal bestimmten normalen Betrag von $M(\eta^2)$, der zu dem gemessenen $2a$ gehört, annimmt, verzichtet er für die einzelne Stunde auf einen genauen, ja oft selbst auf einen auch nur einigermassen genäherten Wert der Aktivität; aber er nimmt mit Recht an, dass der Durchschnitt zahlreicher Stunden (so das Monatsmittel einer bestimmten Tagesstunde oder das Tagesmittel) hinreichend genau erhalten wird. Eine gewisse Ausgleichung der Fehler ist übrigens schon bei der Zusammenfassung der von den drei Komponenten gelieferten Einzelwerte in eine Summe, die die eigentliche Aktivität liefert, zu erwarten. Immerhin ist es vorzuziehen, einzelne Stunden mit ungewöhnlich grossen Schwankungen nicht auf dem schematischen Wege, sondern durch direkte Bestimmung von $M(\eta^2)$ auszuwerten, zumal da der von ihnen gelieferte hohe Beitrag auch noch Mittelwerte aus zahlreichen Stunden stark beeinflusst.

Es liegt nun nahe, zu erwarten, dass $M(\eta^2)$ mit a^2 wenigstens annähernd proportional sein werde, was die sachliche Voraussetzung einschliesst, dass sich die verschiedenen erdmagnetischen Oscillationen nur der Grösse, aber nicht ihrem Wesen nach unterscheiden, mit andern Worten, dass der allgemeine Charakter des Verlaufs bei allen, gleichgültig wie stark sie sind, derselbe sei. Diese Vermutung hat sich im wesentlichen als richtig erwiesen. Abweichungen davon bei den kleinsten Werten von a erklären sich zwanglos aus dem Einfluss der Abrundung, solche bei sehr grossen Werten von a sind bei deren Seltenheit vielleicht als zufällig anzusehen. Doch verstärkt ihr Vorkommen das Gewicht der schon betonten Notwendigkeit, im Falle starker Stundenamplituden $M(\eta^2)$ aus genügend zahlreichen Ordinaten y zu bestimmen und nicht dafür den aus a abgeleiteten Durchschnittswert zu verwenden.

Für den Faktor c in der Beziehung

$$M(\eta^2) = c\,a^2 = CR^2, \text{ wie Chree schreibt,}$$

ergeben die Seddiner Beobachtungen den bis zu sehr grossen Werten von a gut stimmenden Wert

$$c = 0.35, \text{ also } C = c:4 = 0.088$$

Bei den allerhöchsten Amplituden ergibt sich c etwas niedriger; von $a = 35$ (mm) bis $a = 100$ findet sich im Durchschnitt 0.27; doch ist nach dem Gesagten darauf kein grosses Gewicht zu legen. (Bemerkt sei, dass $M(\eta^2)$ in allen Fällen, in denen $a > 10$ war, durch Messung von 10 Ordinaten bestimmt worden ist. Es waren dies bei der hohen Empfindlichkeit der Seddiner Instrumente im ganzen 710 Fälle, davon 421 bei X, 273 bei Y und 16 bei Z, d. h. durchschnittlich rund ein Vierzigstel aller Stunden.)

Das Seddiner Ergebnis kommt dem nahe, das Chree aus einem umfangreichen Material von zahlreichen Stationen abgeleitet hat. Für Werte von R zwischen 0.3 und 2.4 fand er $C = 0.094$, also $c = 0.38$, und aus einer weiteren Zusammenstellung, die in R von 0.5 bis 10 gilt, $C = 0.092$, also $c = 0.37$ (a. a. O. S. 69, 70). Nur wenig grösser, $C = 0.100$, $c = 0.40$, ist der von Hazard aus den Beobachtungen von Cheltenham (1915) abgeleitete Wert, während sich aus Bidlingmaiers Bearbeitung der Beobachtungen von Wilhelmshaven (1911, Januar bis Juni) der nicht unwesentlich höhere Wert $c = 0.45$ ergeben hat. Es hat danach fast den Anschein, als ob der Verhältnisfaktor etwas vom Orte und vielleicht auch von der Zeit (etwa innerhalb der Sonnenfleckenperiode) abhinge, was freilich schwer verständlich wäre.[7]

Praktisch sind die gefundenen Unterschiede ohne Bedeutung, wenn man die Auswertung von $M(\eta^2)$ durch ca^2 auf die (die grosse Mehrzahl bildenden) Fälle beschränkt, in denen a einen nicht zu hohen Wert erreicht. Für $a = 5$ oder $R = 10$, also einen bereits beträchtlichen Wert der Stundenschwankung, ergibt sich aus einer Aenderung von c um 0.05 (um mehr weichen die gefundenen Einzelwerte von ihrem Durchschnitt nicht ab) in $M(\eta^2)$ erst eine solche um 1.25 und bei einem Skalenwert von $e = 5\gamma$ gibt dies in $A_h^x = e^2 M(\eta^2) : 8.\pi$ nur 1.25 ϵ. Die aus der Verschiedenheit der Werte von c entspringende Unsicherheit bleibt danach wesentlich hinter der Ungenauigkeit zurück, die durch die Gleichsetzung von $M(\eta^2)$ mit ca^2 im einzelnen Falle begangen wird, und auch der etwaige

[7] Es ist hier der gegebene Ort, auf zwei Arbeiten hinzuweisen, die eine verwandte Frage, nämlich die nach dem Verhältnis des maximalen zum mittleren Fehler bei Beobachtungen behandeln, die erste auf empirischer Grundlage, die zweite theoretisch: J. Hartmann, *Maaletcknik*, København, 1914 und K. Molin, Om sannolikheten för uppkomsten af det maximala felet hos ett mätresultat. *Norsk Mat. Tidsskrift*, 11 (2) 1920.

systematische Fehler spielt keine Rolle, weil A_h^x, wie auch Hazard mit Recht hervorhebt, gegen A_d^h im allgemeinen sehr zurücktritt, so dass A_d^x und A_a^x dadurch relativ noch weniger als A_h^x selbst berührt werden.

Im Folgenden sollen nun einige Ergebnisse mitgeteilt und besprochen werden, die nach der erwähnten Voruntersuchung aus der Bearbeitung der Seddiner Kurven des Jahres 1915 gewonnen worden sind. Ich betrachte dabei ausschliesslich die Gesamtaktivität, die sich aus den von den drei Komponenten X, Y, Z gelieferten Teilwerten zusammensetzt. Diese drei Anteile stehen im Mittel ungefähr im Verhältnis von 1 : 1 : 0.2, so dass der Beitrag der vertikalen Komponente ein Zehntel desjenigen der horizontalen ausmacht. Die Einheit der Zahlen ist überall ϵ, d. i. 10^{-10} erg cm^{-3}, was mit γ^2 identisch ist.

1. Jahresmittel des taeglichen Ganges der Aktivitaet.

Für die auf das Tagesmittel als normalen Zustand bezogene Aktivität A_d^x ergeben die Seddiner Beobachtungen die Zahlen der ersten Reihe der nachstehenden Tabelle. Die Zeitangaben sind nach Weltzeit, die mit mittlerer bürgerlicher Greenwicher Zeit übereinstimmt, gemacht; die Ortszeit ist um 52^m grösser.

Diese Zahlen geben von dem, was man durch den Begriff der Aktivität schärfer zu erfassen strebt, ein ganz unzutreffendes Bild. Die Tatsache, dass in Seddin (wie überhaupt in Mitteleuropa) das Maximum der magnetischen Unruhe ganz unzweifelhaft auf die Nachmittags- und Abendstunden fällt, wird darin vollkommen unterdrückt. Es liegt dies an dem überwiegenden Einfluss der in den Zahlen mit berücksichtigten täglichen Schwankung, die am Vormittag und um Mittag herum die stärksten Abweichungen vom Tagesmittel aufweist.

Um diesem Uebelstand zu begegnen, zieht Bidlingmaier den normalen Betrag dieses Einflusses, den er aus den Monatsmitteln des täglichen Ganges berechnet, von den Werten von A_d^x ab und betrachtet den Rest als Aktivität der Störungen. Hier ergeben sich auf diese Weise die in der zweiten Reihe der Tabelle 1 stehenden, als A_h bezeichneten Zahlen. In diesen tritt die erwähnte Tatsache deutlich hervor. Trotzdem ist auch das so verbesserte Verfahren zu verwerfen, weil es in den Monatsreihen vielfach auf negative Werte führt, die wegen der physikalischen Bedeutung der Aktivität als einer Energiedichte sinnlos sind.

TABELLE 1

Stunde	0^h-1^h	1^h-2^h	2^h-3^h	3^h-4^h	4^h-5^h	5^h-6^h	6^h-7^h	7^h-8^h	8^h-9^h	9^h-10^h	10^h-11^h	11^h-12^h
A_d^x 1915	17	15	13	14	16	20	22	24	27	29	36	47
A_h "	13	12	9	8	5	6	3	1	2	2	2	10
A_h^x "	2.5	2.2	1.5	1.6	1.2	1.2	1.4	1.7	2.0	1.7	2.2	1.7
N "	4.6	4.6	4.2	3.7	3.3	3.1	2.8	2.3	2.1	2.6	3.3	3.6
N 1905–15	4.2	3.9	3.7	3.3	3.1	3.0	2.9	2.9	3.1	3.3	3.5	3.8

Stunde	12^h-13^h	13^h-14^h	14^h-15^h	15^h-16^h	16^h-17^h	17^h-18^h	18^h-19^h	19^h-20^h	20^h-21^h	21^h-22^h	22^h-23^h	23^h-24^h
A_d^x 1915	46	38	26	20	19	21	22	18	19	18	18	16
A_h "	10	11	9	12	13	14	15	11	13	13	12	10
A_h^x "	1.6	1.9	2.4	2.8	4.0	4.9	4.0	2.9	3.1	3.2	3.5	3.0
N "	4.0	4.3	4.5	4.8	4.8	5.2	5.4	5.3	5.4	5.5	5.6	5.0
N 1905–15	4.0	4.0	4.2	4.5	4.8	5.1	5.4	5.5	5.8	5.8	5.3	4.9

Am einfachsten und zugleich am besten dürfte es sein, von der täglichen Schwankung überhaupt abzusehen und nur die innere Stundenunruhe zu berücksichtigen, d. h. ausschliesslich A_h^x als Mass der Aktivität zu benutzen. Die damit verbundene, nur an polaren Stationen beträchtliche Steigerung von A_d^h ist daneben durch eine besondere Angabe zu kennzeichnen. Die aus den Seddiner Kurven für 1915 abgeleiteten Werte von A_h^x findet man in der dritten Zeile der vorstehenden Tabelle. Sie zeigen entschieden den zuvor angegebenen täglichen Gang der Störungsneigung.

Dasselbe tut eine wesentlich einfacher zu gewinnende Darstellung, die unter der Bezeichnung N in den zwei letzten Zeilen der Tabelle zu finden ist, einerseits zum unmittelbaren Vergleich mit den vorhergehenden Angaben gleich diesen für 1915, andrerseits für den Durchschnitt der 11 Jahre 1905–1915. Es ist dies die relative Häufigkeit der gestörten Stunden in Hundertteilen ihrer Anzahl für den ganzen Tag. (Die Zahlen sind aus denen für die absolute Häufigkeit unter Zusammenfassung der drei Komponenten abgeleitet. Vgl. *Erg.* 1915, S. 25). Ihr Ver-

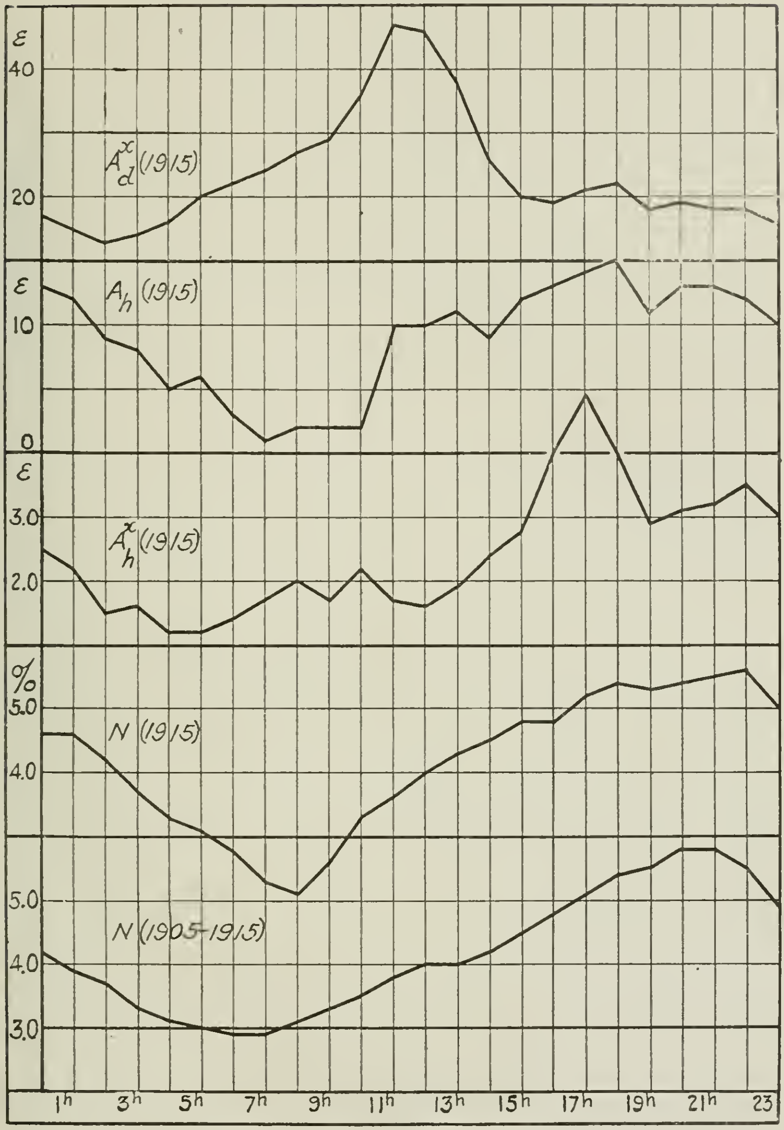

FIG. 1.—TAEGLICHER GANG DER AKTIVITAET.

lauf ist, wie man am besten aus der hier beigefügten graphischen Darstellung der Tabelle ersieht, dem von A_h und A_h^x ganz ähnlich, wenn man bei diesen von dem stark herausfallenden Werte von A_h^x für die Stunde (17^h–18^h) absieht. Dieser wird ausschliesslich durch die starke Störung vom 17. Juni 1915 hervorgerufen. Der durch dieses Beispiel veranschaulichte übermässige Einfluss, den ein einziger sehr stark gestörter Stundenwert infolge der Quadrierung selbst noch im Jahresmittel haben kann, ist ein Uebelstand, der im Wesen der Methode begründet liegt und daher auf keine Weise zu vermeiden ist. Er wird noch dadurch verschlimmert, dass solche ungewöhnlich starken Abweichungen meistens nur auf einem engen Gebiet gleichzeitig auftreten, also an sich nicht eine so überragende Bedeutung besitzen, und dass der von ihnen gelieferte Beitrag zur Aktivität auch bei genauer Berechnung sachlich unsicher ist, weil er von der zufälligen Begrenzung der Stundenabschnitte abhängt.

Bedenkt man nun noch, dass die Aktivitätszahlen im wesentlichen nur zur allgemeinen Orientierung und zu statistischen Untersuchungen (Aufsuchung von Periodizitäten u. dgl.) geeignet sind, dass aber ihre Einführung in exakt definierte physikalische Beziehungen trotz ihrer scharf bestimmten Bedeutung als einer Energiedichte schwerlich jemals in Frage kommen dürfte, so scheint es gerechtfertigt, dem einfachsten Verfahren den Vorzug zu geben, wenigstens soweit es sich um die allgemeine Einführung in die Praxis der Observatorien handelt. Das ist unzweifelhaft die Auswahl und Auszählung der gestörten Stunden, die freilich etwas Willkürliches an sich hat, und deren Ergebnisse etwas von ihrer zugrundegelegten Definition abhängen werden. (Vgl. dazu *Erg.* 1905, S. 35–37 und *Erg.* 1900–1910, S. 48). Man könnte allerdings auch ein streng definiertes objektives Verfahren, wie es Sabine und in feinerer Ausbildung später van der Stok[8]) vorgeschlagen und benutzt hat, anwenden; aber damit ginge dann der Hauptvorteil der Auszählung, ihre Einfachheit und schnelle Ausführbarkeit, verloren. Ohne diesen Vorteil aufzugeben, könnte man dagegen das Verfahren noch etwas verfeinern, indem man nach Bidlingmaiers Vorgang schwach und stark gestörte Stunden unterscheidet, also ebenso wie bei der Charakterisierung der Tage drei Stufen (0, 1. 2) der Gestörtheit einführt, auf die man die Stunden verteilt[9]). Uebrigens dürfte es genügen, wenn diese Arbeit an jeder Station

[8] *Observations made at the Magn. and Met. Obs. at Batavia*, Vol. VI, Part II. Supplement, and Vol. VII, Introduction.

[9] Wilhelmshaven: *Uebersicht über die Tätigkeit des Erdmagnetismus.* 1910–1912.

während einer begrenzten Reihe von Jahren (am besten eine Sonnenfleckenperiode lang) durchgeführt und dann zugunsten anderer Aufgaben abgebrochen wird. Der allgemeine Charakter des täglichen Verlaufs der Störungsneigung (Lage der Maxima und Minima, ihr genähertes Grössenverhältnis u. dgl.) dürfte dadurch wohl hinreichend zu ermitteln sein.[10])

Will man aber von jeder subjektiven Auffassung freie Werte haben, so empfiehlt sich, wie schon bemerkt, die Wahl von A_h^x und die getrennte Berücksichtigung des täglichen Ganges der Stundenmittel, freilich ein recht umständliches Verfahren, zumal da doch schliesslich nur Mittelwerte für längere Zeiten (Monate u. s. w.) abgeleitet werden und sachliche Bedeutung besitzen. Ich habe deshalb (vgl. *Erg.* 1915, 16, 17 im Abschnitt Ergebnisse) den Versuch gemacht, die monatliche Schwankung der einzelnen Tagesstunden, d. h. den Unterschied des höchsten und des niedrigsten Betrags, den jede während eines Monats gehabt hat, zu benutzen. Doch haben sich diese Zahlen gerade für die Charakterisierung des mittleren täglichen Ganges der Unruhe als wenig geeignet erwiesen. Das war übrigens vorauszusehen, da sie in unübersichtlicher Weise durch die Schwankungen im Verlauf der Tagesmittel beeinflusst werden.

2. Die Aktivitaet der einzelnen Tage.

Auch hier gibt A_h^x, von dem natürlich das Tagesmittel zu nehmen ist, dasjenige Bild, das dem unmittelbaren Eindruck der Kurven am besten entspricht. Die in A_d^x noch hinzukommende, durch das Tagesmittel von A_d^h ausgedrückte tägliche Schwankung ist für den Störungsgrad des Tages wenig bezeichnend; sie ist (wenn man von polaren Gegenden absieht) an ruhigen Tagen manchmal stärker als an unruhigen und ändert sich vor allem beträchtlich im Laufe des Jahres. Da sie überdies, ausser an stark gestörten Tagen, A_h^x wesentlich an Grösse übertrifft, so kommt dieses in der Summe A_d^x wenig zur Geltung. Was schliesslich A_a^x betrifft, so ist von dem darin enthaltenen A_a^d Aehnliches zu sagen; vor allem aber ist zu bedenken, dass es an den auf eine starke Störung folgenden Tagen noch recht hohe Werte besitzt, gleichgültig ob diese selbst ruhig oder noch gestört sind. Man wird daher besser tun, die in A_a^d zum Ausdruck kommende Erscheinung (die sogenannte Nachstörung) für sich zu behandeln.[11]

[10] Das bestätigen die nach zwei verschiedenen Definitionen durchgeführten Auszählungen an den Potsdamer Kurven von 1905. Vgl. *Erg.* 1905, S. 37 und Tafel V. Die langjährigen Reihen von 1890–99, 1900–05, 1905–10 weisen allerdings stärkere Unterschiede auf, was vielleicht mit systematischen Schwankungen innerhalb der Sonnenfleckenperiode zusammenhängt.

[11] Vgl. darüber den Aufsatz im vorigen Hefte dieses Journals: Ein Mangel der erdmagnetischen Jahrbücher.

Ein recht gutes Bild von der magnetischen Unruhe der einzelnen Tage geben sicherlich auch die Tagessummen der absoluten Abweichungen der Stundenwerte von einem ausgeglichenen Verlauf, wie sie van der Stok bei seiner vorhin schon erwähnten Methode zur Absonderung der als gestört zu betrachtenden Stundenwerte bestimmt hat.[12] Zur allgemeinen Einführung eignen sie sich indessen ebenso wenig wie die A_h^x, weil sie mindestens denselben grossen Arbeitsaufwand wie diese erfordern. Eher könnte die gleichfalls ohne Rücksicht auf das Vorzeichen zu bildende Summe der Abweichungen vom Tagesmittel Verwendung finden, die annähernd dem Anteil A_d^h entspricht.[13] Doch findet auch auf sie das oben über dieses Gesagte Anwendung. Ausdrucksvoller, aber mehr von Zufälligkeiten abhängig ist die tägliche Amplitude, der Unterschied der beiden äussersten Werte; sie hat den grossen Vorzug der denkbar einfachsten Ermittelung, zumal wenn man nicht die absoluten Extreme, sondern die extremen Stundenwerte zugrunde legt. (Aus dreijährigen nach beiden Arten bearbeiteten Aufzeichnungen in Potsdam ergab sich dafür ein mittleres Grössenverhältnis von 9 : 7. Vgl. *Erg.* 1915, S. 24). Zweckmässig ist es, die Amplituden der drei Elemente in eine Zahl zusammenzufassen, und zwar der Einfachheit halber durch Addition ihrer Beträge. Hat ihre Summe auch keine physikalische Bedeutung, so kann man ihr doch eine konventionelle beilegen, und das genügt für den Zweck, eine Intensitätsskala der Gestörtheit der Tage zu schaffen. Ich habe in den letzten Potsdam-Seddiner Jahrbüchern eine quadratische Zusammenfassung der Einzelamplituden benutzt, die natürlich etwas grösseren Arbeitsaufwand erfordert. Einen physikalischen Sinn haben aber auch die so gewonnenen (dort A genannten) Zahlen streng genommen nur, wenn die Extreme der drei Elemente zeitlich zusammenfallen. Es ist daher wohl am besten, auf diese mehr scheinbare als wirkliche Verfeinerung zu verzichten und durch Beschränkung auf das allereinfachste Verfahren seine allgemeine Anwendung zu erleichtern. Die Zusammenfassung der Ergebnisse zahlreicher Observatorien gewährt dann obendrein die Möglichkeit, zu sachlich bedeutungsvolleren, für die Erde als Ganzes geltenden Werten der Aktivität zu gelangen.

Nun liegt es aber nahe, an ein noch einfacheres, weil schon vor-

[12] Es sind die im Jahrbuch von Batavia in den Tabellen *D* zusammengestellten Zahlen.

[13] Diese Zahlen hat van der Stok für die 16 Jahrgänge 1873–1888 der Beobachtungen von Petersburg-Pawlowsk (als Grundlage für eine Untersuchung über die 26-tägige Periodizität) berechnet und dankenswerter Weise ausführlich veröffentlicht. *Batavia Observations*, Vol. XII, Appendix.

handenes Mittel zur Kennzeichnung der einzelnen Tage zu denken—an die internationalen Charakterzahlen. Diese erweisen sich in der Tat als sehr geeignet dazu; ein Vergleich mit den Bidlingmaierschen Aktivitätszahlen A_h^x zeigt eine geradezu überraschende Aehnlichkeit des Verlaufs. Nach der Feststellung in *Erg.* 1915, S. 35, zeigten beide an 289 Tagen des Jahres 1915 gleichsinnige Aenderungen (d. h. beide stiegen an, blieben unverändert oder fielen), dagegen nur 21 mal entgegengesetzte (d. h. die eine Zahl wuchs, während die andre abnahm), während in den übrigen 54 Fällen die eine ihren Wert behielt, indes die andere sich änderte. In nahezu allen Fällen nicht gleichsinniger Bewegung handelte es sich überdies nur um geringfügige Unterschiede. Besonders augenfällig wird die grosse Aehnlichkeit des Verlaufs, wenn man nicht das Tagesmittel der Stundenunruhe A_h^x selbst, sondern den Betrag $\sqrt{8\pi\, A_h^x}$ des ihr entsprechenden Vektors mit der Charakterzahl ν vergleicht, wie es a. a. 0. für das ganze Jahr in graphischer Darstellung geschehen ist. Die nebenstehende Figur zeigt als Beispiel den Verlauf während der Monate Mai und Juni 1915. (Beim Vergleich ist zu beachten, dass a. a. O. als Einheit von A_h^x nicht ϵ, sondern 0.1ϵ verwendet worden ist, was im Vektor zu $\sqrt{10}$ mal so grossen Masszahlen führt. Daraus erklärt sich die Aenderung in der Bezifferung der Ordinaten.) Die starke Störung vom 17. Juni macht sich auch hier bemerklich und lässt erkennen, dass eine graphische Darstellung von A_h^x selbst ganz unzweckmässig sein würde.

Auch eine Vergleichung von ν mit den oben erwähnten, aus den Tagesamplituden abgeleiteten Werten A lässt eine sehr weitgehende Aehnlichkeit des Verlaufs von Tag zu Tag erkennen. Es

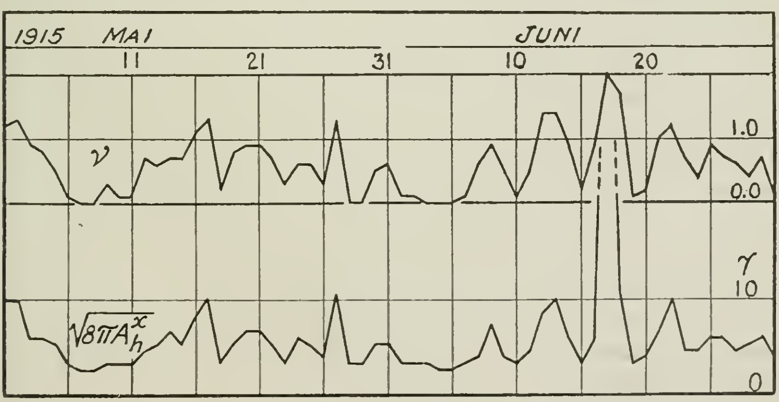

Fig. 2.—Aktivitaet der Einzelnen Tage.

kann danach kaum ein Zweifel daran bestehen, dass die internationalen Charakterzahlen ein sehr brauchbares Mittel zur Kennzeichnung der von Tag zu Tag wechselnden Aktivität bilden. Zugleich darf man mit grosser Wahrscheinlichkeit schliessen, dass diese Aktivität einen der ganzen Erde gleichmässig zukommenden, von örtlichen Bedingungen im wesentlichen unabhängigen Zustand darstellt. Es wäre sonst seltsam, dass die aus den Vorgängen an einem einzelnen Orte (Seddin) abgeleitete Aktivität mit den aus den Stufenschätzungen sämtlicher Observatorien bestimmten Charakterzahlen so vorzüglich im Einklang steht. Das bestätigt im übrigen die Auffassung, dass in der Aktivität die im wesentlichen nur in ihrer Stärke schwankende, die Erde als Ganzes beeinflussende Wirkung der Sonne zum Ausdruck kommt.

3. Die mittlere Aktivitaet der Monate und des Jahres.

Aus der Aktivität der einzelnen Tage erhält man ohne weiteres durch einfache Mittelbildung diejenige beliebiger Gruppen von Tagen, seien es nun solche, die man nach irgend einem Gesichtspunkte (zur Aussuchung eines vermuteten Einflusses) auswählt, seien es diejenigen eines zusammenhängenden Zeitabschnitts, etwa eines Jahres oder Monats. Da in diesem zweiten Falle rein äusserlich eine Zusammenfassung innerhalb sachlich zufälligen Grenzen stattfindet (wenigstens gilt dies von den Monatsmitteln), die oft mit weitgehender Ausgleichung charakteristischer Schwankungen verbunden ist, so können die so erhaltenen Werte nur eine statistische Bedeutung besitzen und einen Ueberblick in allgemeinen Zügen über den Verlauf der Erscheinungen während längerer Zeiträume liefern. Um aber auch nur dies in zutreffender Weise zu tun, bedürfen sie einer viel strengeren, objektiven Grundlegung als da, wo es sich nur um die Vergleichung des Zustandes während kürzerer Zeiten handelt. Daher scheidet hier die Verwendung der Charakterzahlen aus. Wenn diese auch während einer kürzeren Reihe von aufeinanderfolgenden Tagen recht gut vergleichbar sind, so lässt sich doch nicht erwarten, dass der Masstab der zugrunde liegenden Stufenschätzungen lange Zeit hindurch festgehalten werden wird. Im Gegenteil sind nicht nur zufällige, sondern auch systematische Aenderungen darin sehr wahrscheinlich. In störungsreichen Zeiten wird man geneigt sein, die Grenzen zwischen den einzelnen Stufen etwas nach oben zu verschieben, in ruhigen sie tiefer anzunehmen.[14]

[14] Nach den bisherigen Erfahrungen ist dies allerdings nicht in dem Masse der Fall, wie man es wohl erwarten könnte. Vgl. Die Internationalen Erdmagnetischen Characterzahlen. *Met. Zeitschr.*, 1916, S. 491.

Fällt hiernach für den vorliegenden Zweck die Benutzung der Charakterzahlen wegen ihrer subjektiven Grundlage weg, so ist ebenso wenig an die Verwendung der Aktivitätswerte zu denken, die sich nach den Verfahren von Bidlingmaier oder van der Stok ergeben, weil diese unverhältnismässig grosse Arbeit erfordern. Es bleibt daher kaum etwas anderes übrig, als die Benutzung der täglichen Amplituden. Wenn diese auch wohl für die einzelnen Tage wegen zu starker Zufallswirkungen nicht ganz ausreichen, so geben sie doch im Mittel einer grösseren Zahl von Tagen, indem diese Zufälligkeiten ausgeglichen sind, sicherlich ein gutes Bild. Entsprechendes gilt auch von der früher erwähnten monatlichen Schwankung der Tagesstunden. Die Werte für die einzelnen Stunden sind zu unregelmässig beeinflusst, als dass sie den täglichen Gang zutreffend charakterisieren könnten; das Mittel aller 24 Werte darf dagegen wohl als kennzeichnend für den Monat gelten. Hier mag es indessen genügen, nur die erste Möglichkeit zu verfolgen. Dabei soll die schon im Vorhergehenden erwähnte und trotz ihrer rein konventionellen Bedeutung als brauchbar erkannte additive Zusammenfassung der drei Komponenten Anwendung finden.

Eine demgemäss nach den Seddiner Beobachtungen von 1915 aufgestellte Berechnung liefert die nachstehende Uebersicht des Aktivitätsverlaufs im genannten Jahre. Die erste Zeile enthält unter der Bezeichnung A die Monatsmittel der Summe der täglichen Amplituden von X, Y, Z. Unter Amplitude ist hier die Differenz der extremen Stundenmittel verstanden. Es würde nichts wesentliches geändert werden, wenn man die Differenz der absoluten Extreme nähme. Die Bemerkung von Chree, a. a. O. S. 82, wonach letztere eine bessere Uebereinstimmung mit Bidlingmaiers Aktivität zeigten, als die ersteren, ist für die Monatsmittel ohne Belang, sie gilt nur für die einzelnen Tage. Den Zahlen liegen die Angaben der Tabelle in *Erg.* 1915, S. 23, zugrunde. Ein unmittelbar zutreffendes Bild der Aktivität können sie nicht abgeben, da sie durch den starken jährlichen Gang der täglichen Variation beeinflusst werden. Es ist daher angezeigt, die Amplitudensummen der Monatsmittel des täglichen Ganges davon abzuziehen. Und zwar erscheint es am richtigsten, den Minimalbetrag dieses Ganges, wie er zur Zeit vollkommen erloschener Sonnentätigkeit stattfindet, zu wählen. Setzt man in bekannter Weise die tägliche Variation $\triangle$ einer linearen Funktion der Sonnenflecken-Relativzahl R gleich, $\triangle = \triangle' + 0.01R.\ \triangle''$, so bezeichnet $\triangle'$ diesen der Aktivität 0

entsprechenden Gang. Für Potsdam-Seddin habe ich diese Zerlegung von $\triangle$ nach den Beobachtungen der 11 Jahre 1900–1910 ausgeführt. (Vgl. *Erg.* 1900–1910, S. 45 u. (36), (37)). Die daraus folgenden, hier als $\triangle'$ bezeichneten kleinsten Amplitudensummen stehen in der zweiten Zeile der Uebersicht (Tabelle 2).

TABELLE 2.

1915	Jan.	Febr.	Mär.	Apr.	Mai	Juni	Juli	Aug.	Sept.	Okt.	Nov	Dez.	Jahr
A	09	85	126	144	134	166	153	150	141	147	132	76	127
$\triangle'$	39	39	74	96	89	101	95	103	83	75	44	33	73
$\triangle_m$	48	61	93	121	121	122	118	119	104	87	58	43	93
$0.8\triangle_m$	38	49	74	97	97	˚98	94	95	83	70	46	34	73
A_0	31	36	52	47	37	68	59	55	58	77	86	42	54
α	0.42	0.49	0.71	0.64	0.51	0.93	0.81	0.75	0.79	1.06	1.18	0.58	0.74
(α)	57	67	96	87	69	126	109	102	107	143	160	78	100

Da aber von andern Observatorien die Werte von $\triangle'$ nicht vorliegen, so ist es der Gleichförmigkeit halber besser, die mittlere Variation $\triangle_m$ (die natürlich aus einer längeren Reihe von Jahren, am besten einer Sonnenfleckenperiode, zu berechnen ist) zugrunde zu legen, indem man sie mit einem passenden Reduktionsfaktor multipliziert. Hier ergibt sich für diesen der Betrag 0.80. Wie man sieht, stimmt $0.80\triangle_m$ mit $\triangle_0$ sehr nahe überein. Annähernd wird man diesen Wert auch anderwärts benutzen können; aber besser ist es natürlich, ihn für jeden Ort besonders zu berechnen, was eine geringfügige Arbeit ist, wenn man sich darauf beschränkt, eine Anzahl von Jahresmitteln der täglichen Amplitude in der Form $\triangle' + 0.01R.\triangle''$ darzustellen und den für $\triangle'$gefundenen Wert mit dem Durchschnitt $\triangle_m$ dieser Mittel zu dividieren.

Die Differenz ($A - 0.8\triangle_m$) findet sich oben unter der Bezeichnung A_0 und stellt die absolute Aktivität dar. In ihr kommt einerseits die Störungshäufigkeit und Stärke, andererseits die Steigerung der normalen täglichen Variation über ihren Minimalbetrag $\triangle'$ hinaus zum Ausdruck. Zweckmässig erscheint es, um die Ergebnisse verschiedener Observatorien bequemer vergleichen und zusammenfassen zu können, daneben eine relative Aktivität einzuführen, indem man A_0 durch einen für den Ort charakteristischen Mittelwert dividiert. Ich wähle den Jahresdurchschnitt von 0.8 $\triangle_m$, d. i. 73γ. Die Quotienten $\alpha = A_0 : 73$ stehen in der vorletzten Zeile der Tabelle, während in der letzten (α) die auf das Jahresmittel 100 angerechneten Werte von A_0 oder α bezeichnet, die in der nebenstehenden Figur graphisch wiedergegeben sind.

Figur 3, die zum Vergleich der auf verschiedenen Wegen erhaltenen, sämtlich in Prozenten des Jahresmittels ausgedrückten Aktivitätszahlen dienen soll, enthält ausser (α) drei Darstellungen, die dem schon wiederholt genannten Jahrbuch *Erg.* 1915, S. 34, entnommen sind. Die erste Kurve (s) beruht auf den Aktivitätszahlen nach Bidlingmaier und ist als die massgebende zu betrachten, nach der die anderen zu beurteilen sind. Die zweite, (S), ist in ähnlicher Weise wie die dritte, (α), abgeleitet worden, jedoch unter durchgängiger quadratischer Mittelbildung; die vierte, (ν), stellt den Gang der Charakterzahlen dar. Die Hauptzüge des Verlaufs sind überall dieselben; besonders auffällig ist wieder der stark hervorstechende Einfluss der Junistörung in (s). Der Vergleich mit (s) zeigt im übrigen, dass (S) sowohl wie (α) als befriedigender

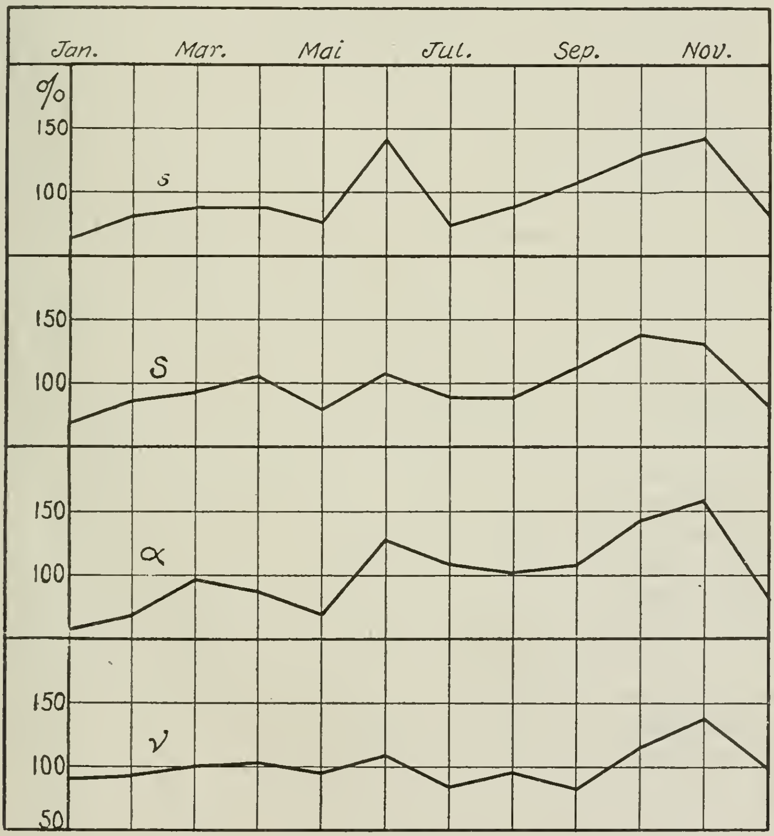

Fig. 3.—Gang der Aktivitaet im Jahre 1915 in Monatsmitteln.

Ersatz dafür gelten darf. Die einfachere Berechnungsweise lässt aber dem (α) gegenüber dem (S) den Vorzug geben.

Sonach erscheint der Vorschlag begründet, als allgemein anzuwendendes Mass der mittleren Aktivität der Monate die Relativzahlen α einzuführen. (Nicht (α), das hier nur zur Erleichterung der Vergleichung benutzt worden ist, das aber den Unterschied der Jahre verwischt.) Um einen Ueberblick über die damit zu gewinnenden Resultate zu geben, stelle ich die Werte dieser Grösse nach den Seddiner Beobachtungen aus den Jahren 1908–1917 hier zusammen (Tabelle 3).

TABELLE 3.

	Jan.	Febr.	März	April	Mai	Juni	Juli	Aug.	Sept.	Okt.	Nov	Dez.	Jahr
1908	0.56	0.78	1.08	0.74	0.78	0.59	0.56	1.04	1.96	0.78	0.71	0.41	0.83
09	1.16	0.58	0.89	0.53	0.81	0.45	0.42	0.66	1.59	0.82	0.51	0.74	0.76
10	0.62	0.53	0.84	0.63	0.46	0.59	0.41	0.79	0.77	1.04	0.70	0.74	0.68
11	0.79	1.03	0.77	0.62	0.47	0.30	0.47	0.26	0.37	0.45	0.38	0.45	0.53
12	0.19	0.16	0.16	0.23	0.26	0.41	0.27	0.30	0.40	0.29	0.29	0.30	0.27
13	0.30	0.27	0.23	0.29	0.18	0.29	0.19	0.16	0.29	0.37	0.21	0.18	0.25
14	0.12	0.19	0.25	0.36	0.27	0.41	0.51	0.23	0.55	0.40	0.45	0.37	0.34
15	0.42	0.49	0.71	0.64	0.51	0.93	0.81	0.75	0.79	1.06	1.18	0.58	0.74
16	0.67	0.62	1.42	1.07	1.00	0.97	0.95	0.97	1.03	1.17	1.12	0.85	0.99
17	1.16	1.00	0.84	0.88	0.82	1.26	1.25	1.96	1.07	1.32	0.85	1.19	1.13

In erster Annäherung wird man diese Zahlen für die ganze Erde gelten lassen dürfen. Es ist aber natürlich zu wünschen, dass sie auch für eine Anzahl anderer Observatorien berechnet werden, damit einerseits der Grad der Uebereinstimmung zwischen den Ergebnissen von verschiedenen Orten bearbeitet werden kann, andrerseits eine Verschärfung durch Mittelbildung möglich ist. Da die zu ihrer Ableitung nötige Arbeit ganz unbedeutend ist, so steht der Erfüllung dieses Wunsches kein ernstes Hindernis entgegen.

Wenn auch das Verfahren Bidlingmaiers wegen der damit verknüpften, übermässigen Arbeit, die zur Bedeutung der damit erzielten Ergebnisse nicht im richtigen Verhältnis steht, keinen Eingang in die allgemeine Praxis finden kann, so hat es doch, wie auch das Vorhergehende zeigt, einen grossen Wert insofern, als es eine objektive Prüfung der Brauchbarkeit anderer, bequemerer Rechenverfahren ermöglicht. Es wäre erfreulich, wenn es dazu auch weiterhin gelegentlich Anwendung fände.

BEMERKUNG UEBER DIE VERWENDUNG VON STUNDENMITTELN.

Von Adolf Schmidt.

Die Korrektion, auf die Herr Chree in der Notiz "Concerning procedure at magnetic observatories" hinweist (*Terr. Mag.*, vol. 25, p. 33), findet sich schon mehrmals in der Literatur behandelt, meistens wohl auf Grund selbständiger Ableitung ohne Kenntnis ihrer früheren Erwähnung an anderer Stelle. Die Notwendigkeit einer solchen Verbesserung ist auch ohne eingehende mathematische Untersuchung klar. Sie ergibt sich ohne weiteres daraus, *dass der Mittelwert der Ordinaten eines Kurvenstücks im allgemeinen nicht mit der Ordinate im mittleren Punkte identisch ist.* Der Unterschied zwischen beiden ist überdies systematischer Natur; an Stellen negativer Krümmung (wie bei einem Maximum) ist der erste Wert kleiner, an Stellen positiver Krümmung (wie bei einem Minimum) grösser als der zweite.

Diese naheliegende Bemerkung ist aber natürlich nicht erst bei der harmonischen Analyse von Bedeutung, sondern findet schon bei der einfachen Darstellung des täglichen Ganges durch stündliche Werte Anwendung. Ersetzt man diese ohne weiteres durch Stundenmittelwerte, so begeht man einen Fehler, der zwar meistens nur klein ist, aber doch besonders an den Umkehrstellen die zulässige Grenze überschreitet. Die Nichtbeachtung dieses Umstandes trägt wohl auch die Hauptschuld daran, dass Herr Chree die Stundenabschnitte so wählt, dass sie von den Augenblicken voller Stunden halbiert werden, statt so, dass sie von ihnen begrenzt werden. Dagegen habe ich, als ich bei der Auswertung der Potsdamer Kurven im Jahre 1905 zur Verwendung von Stundenmitteln überging, ausdrücklich auf die an diese anzubringende Verbesserung hingewiesen.[1] Die Potsdamer und später die Seddiner Beobachtungen sind auch von da an stets in dieser Weise bearbeitet worden.[2] Da sich die Benutzung der Stundenmittel jetzt nahezu allgemein eingebürgert hat, so erscheint es zweckmässig, hier noch einmal auf die Ableitung des wahren täglichen Ganges aus ihnen einzugehen. Nebenbei sei bemerkt, dass natürlich ganz Entsprechendes u. a. für die Ableitung des jährlichen Ganges aus Monatsmitteln gilt.

In der Umgebung jedes Punktes werde die Kurve so ausgeglichen gedacht, dass ihre Ordinate durch eine quadratische Funktion der Zeit, $y = \alpha + \beta t + \gamma t^2$, dargestellt wird, während die benachbarten Stundenmittel dabei ungeändert bleiben. Für den einzelnen Tag kommt dieses Verfahren im allgemeinen nicht in Betracht, obgleich es auch hier die Möglichkeit einer von Willkür freien Ausgleichung liefert. Seine Anwendung findet es hauptsächlich bei der Behandlung der Monatsmittel des täglichen Ganges. (Die Wahl einer andern Funktion, insbesondere einer über die Glieder 2. Ordnung hinausgehenden Potenzreihe ist natürlich möglich, aber in den meisten Fällen kaum zweckmässig.)

[1] *Ergebnisse der magnetischen Beobachtungen in Potsdam im Jahre 1905*, S. 40.

[2] Es beruht daher auf einem Irrtum, wenn Herr Walker schreibt. . . . "at Seddin, where the hourly value is the estimated mean for an hour centering at the exact hour." (The diurnal variation of terrestrial magnetism. *Proc. Roy. Soc., A*, vol. 89 (1914), p. 380).

Zählt man die Zeit t, in Stunden gemessen, von dem Augenblick an, für den man die ausgeglichene Ordinate y_0 sucht, so hat man $y_0 = \alpha$, und für die Stunden von $t = -\frac{3}{2}$ bis $-\frac{1}{2}$, $-\frac{1}{2}$ bis $+\frac{1}{2}$, $+\frac{1}{2}$ bis $+\frac{3}{2}$ erhält man die Mittelwerte

$$m_{-1} = \alpha - 2\beta + \tfrac{13}{12}\gamma \qquad m_0 = \alpha + \tfrac{1}{12}\gamma \qquad m_1 = \alpha + 2\beta + \tfrac{13}{12}\gamma$$

Hieraus folgt sofort

$$y_0 = \alpha = m_0 - (m_{-1} - 2m_0 + m_1) :24 = m_0 - \tfrac{1}{24}\triangle$$

unter $\triangle$ die zweite Differenz, $\triangle = (m_1 - m_0) - (m_0 - m_{-1})$ der Reihe der m verstanden.

Man erhält also die für die Mitten der einzelnen Stunden geltenden Augenblickswerte, indem man die gemessenen Stundenmittel um den 24. Teil der entsprechenden zweiten Differenzen vermindert. Um die Werte für andere Zeitpunkte, z. B. für die volle Stunde nach Ortszeit, zu erhalten, hat man auf diese, und zwar natürlich wieder unter Benutzung zweiter Differenzen, zu interpolieren. Dabei genügt es, die bereits gebildeten Differenzen der m-Reihe statt der davon nicht wesentlich verschiedenen der y_0-Reihe zu benutzen. Das gewährt den weiteren Vorteil, dass man beide Operationen, die Berechnung der y_0 und die Interpolation, in eine Rechnung zusammenziehen kann, wenn man, wie gewöhnlich, die y_0 nicht weiter braucht.[3]

Die y_0 und ebenso die aus ihnen interpolatorisch abgeleiteten Werte stellen den wahren, wenn auch etwas ausgeglichenen täglichen Gang dar. Sie geben daher auch unmittelbar und ohne nachträgliche Korrektion die mit gleicher Annäherung zutreffenden Werte der Koeffizienten der trigonometrischen Reihe, die diesen Gang ausdrückt. Das ist ohne weiteres einzusehen, aber auch leicht zu erweisen. Die Phase bleibt offenbar (abgesehen von der Verschiebung, die beim Uebergang zu Ortszeit oder einer sonstigen andern Zeitzählung eintritt) ungeändert. Die Amplituden der verschiedenen Wellen ergeben sich, wie eine einfache Rechnung zeigt, bei der y_0-Reihe gegenüber der m-Reihe im Verhältnis von $1 : (1 + \frac{1}{6}\sin^2\frac{1}{2}\omega)$ vergrössert, wenn $\omega = 2\pi :24\,\nu$ bei der ν-ten Welle ist. Der Faktor, mit dem die durch die harmonische Analyse der m-Reihe erhaltenen Amplituden zu multiplizieren sind, lautet nun $\frac{1}{2}\omega : \sin\frac{1}{2}\omega$, d. i. für nicht zu grosse ω, also für die ersten Wellen hinreichend genau, $(1 + \frac{1}{6}\sin^2\frac{1}{2}\omega + \frac{3}{40}\sin^4\frac{1}{2}\omega \ldots)$. Wie man sieht, unterscheidet sich der zuvor angegebene Faktor $(1 + \frac{1}{6}\sin^2\frac{1}{2}\omega)$ hiervon nicht wesentlich. Das tritt noch deutlicher in den Zahlenwerten hervor, die in sachgemässer Abrundung bei den 4 ersten Wellen folgende sind

ν	1	2	3	4
$1 + \frac{1}{6}\sin^2\frac{1}{2}\omega$	1.003	1.011	1.024	1.042
$\frac{1}{2}\omega : \sin\frac{1}{2}\omega$	1.003	1.012	1.026	1.047

[3] Vgl. *Ergebnisse der magnetischen Beobachtungen in Potsdam und Seddin im Jahre 1911*, S. 39.

Die Unterschiede sind ohne jede praktische Bedeutung. Demgemäss ist auch bei der Bearbeitung der Seddiner Beobachtungen vom Jahre 1911 an die harmonische Analyse unmittelbar auf die durch die besprochene Korrektion erhaltene Reihe der stündlichen Augenblickswerte angewendet worden. Eine sachliche Aenderung gegenüber den vorhergehenden Jahren, in denen die Stundenmittel analysiert und die Ergebnisse nachträglich korrigiert worden sind, ist dadurch, wie das Vorhergehende zeigt, nicht eingeführt worden.

WOLFER PROVISIONAL SUN-SPOT NUMBERS FOR JULY, 1919 TO MARCH 1920.

Communicated by G. van Dijk.

Date	1919						1920		
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
1	52	29	51	..	..	77	49	23	18
2	..	14	37	..	..	53	..	19	11
3	91	25	50	..	..	71	..	34	27
4	70	46	57	29	81	71	..	22	37
5	63	59	54	34	..	44	..	26	53
6	36	47	40	26	42	..	16	22	36
7	47	70	45	40	40	..	..	30	34
8	30	61	53	..	39	44	17	31	..
9	..	66	45	..	39	..	15?	33	89
10	62	72	45	80	35	41	..	28	115
11	61	72	51	85	32	33	..	..	110
12	79	83	65	116	..	..	..	41	102
13	..	70	53	..	23	..	34	84	67
14	94	104	53	..	..	40	31	88	31
15	128	112	53	61	15	..	40	96	33
16	80	109	35	56	..	..	37	80	..
17	74	..	40	37	10	..	29	77	92
18	58	101	38	34	..	..	42	79	67
19	63	101	27	18	..	16	40	79	133
20	53	98	50	19	..	8	29	..	134
21	46	111	..	23	11	..	..	81	169
22	..	94	61	..	..	23	69	90	150
23	66	70	73	..	..	..	78	..	161
24	..	61	89	..	50	..	112	53	121
25	92	66	62	..	61	17	130	68	..
26	77	59	79	..	..	16	112	48	83
27	87	37	52	46	44	..	98	38	51
28	59	31	52	..	57	..	113	27	23
29	34	38	..	99	63	11	..	26	31
30	40	..	..	93	61	..	54	..	14
31	25	53	..	113	..	26	..	..	20
Means	64.1	67.6	52.2	56.1	41.4	37.0	57.3	50.9	71.9

Mean for 1919, $R = 63.1$.

For previous table, see *Terr. Mag.*, vol. 24, p. 168.

EARTHQUAKES RECORDED AT WATHEROO OBSERVATORY, MAY, 1920.

EDWARD KIDSON, *Observer-in-Charge.*

The following earthquakes were recorded on the magnetograph of the Watheroo Magnetic Observatory, Western Australia:

Date 1920	Phase	H	D	Z
		h m	h m	h m
May 11	Beginning	2 56	2 55	3 02
	Waves of large amplitude commence	3 01	3 01	.. ..
	Maximum amplitude	1.7 mm.	.. ..	.. ..
		h m		
	Ending	3 04	3 16	3 08
May 13	Beginning	10 02		10 07
	Waves of large amplitude commence	10 09	(No	.. ..
	Maximum amplitude	2.5 mm.	visible	.. ..
		h m	effect)	
	Ending	10 24		10 21

The times are 120th east Meridian standard time. The declination trace on May 11 became too faint during the large waves to measure the amplitude, which was therefore, probably, relatively great.

NOTES

23. *Principal Magnetic Storms at Cheltenham Magnetic Observatory, April to June, 1920.*[1]

Greenwich Mean Time			Range		
	Beginning	Ending	Declination	Hor'l Int.	Vert'l Int.
	h m	h	′	γ	γ
Apr.	15, 0 30	Apr. 15, 18	30.3	252	156

24. *Canadian Geophysical Committee.* Referring to Note 21, we are now able to give, through the courtesy of Dr. Klotz, the full composition of the National Geophysical Committee of Canada: Dr. E. Deville, *chairman*; Dr. O. Klotz, Sir Frederic Stupart, Wm. McInnes, N. Ogilvie, W. J. Stewart, W. Bell Dawson, Prof. L. B. Stewart, Prof. W. R. Brock, E. A. Hodgson, and C. A. French, *secretary.*

[1] Communicated by E. LESTER JONES, Director U. S. Coast and Geodetic Survey; GEO. HARTNELL, Observer-in-Charge; Lat. 38° 44.0′ N.; long., 76° 50.5′ or 5h 07.4m W.

25. *Commission of Terrestrial Magnetism and Atmospheric Electricity of the International Meteorological Committee.* According to page 52 of the "Procès-Verbaux des séances de la Conférence Météorologique Internationale des Directeurs et du Comité Météorologique International, Réunion de Paris, 1919," the Commission was constituted as follows: *President*, A. Angot; *secretary*, E. van Everdingen; Bauer, Carlheim-Gyllensköld, Jaumotte, Krogness, Melander, Palazzo, Riggenbach, Ryder, Sir Napier Shaw, Sir Frederic Stupart, and G. W. Walker. According to a letter from President Angot, the purpose of the recreation of the Commission is to provide the means of intercommunication and of effective coöperation between the International Section of Terrestrial Magnetism and Electricity of the International Geodetic and Geophysical Union, established at Brussels in August, 1919, and the International Meteorological Committee, as reorganized at Paris in September, 1919.

26. *The German Central Office for Earthquake Investigation.* The German Central Office for Earthquake Investigation, formerly at Strassburg in Alsace, has been located at Jena since May, 1919.

27. *Personalia. J. C. Beattie*, principal of the University of the Cape of Good Hope, has been knighted; *Otto Klotz*, director of the Dominion Observatory of Canada, was recently elected at San Francisco, President of the Seismological Society of America; *Colonel H. G. Lyons* has been appointed director and secretary to the Science Museum, South Kensington, in succession to *Sir Francis Ogilvie*, transferred to the Department of Scientific and Industrial Research; *C. T. R. Wilson* has been awarded the Hopkins Prize of the Cambridge Philosophical Society. We regret to be obliged to record the following deaths: *Alexander Supan*, chief of the Geographical Institute of Breslau, in his seventy-third year; *Augusto Righi*, the distinguished Italian physicist, professor in the University of Bologna; *Sir Norman Lockyer*, wellknown for his eminent researches in astrophysics and other sciences, as well as the editor of *Nature*.

28. *Retirement of Dr. Moos.* The following note is taken from the report of Director *T. K. Chinmayanandam* of the Bombay and Alibag Observatories for the year ending December 31, 1919:

"Dr. *N. A. F. Moos*, F. R. S. E., who was the Director of the Observatory for the last twenty-four years, retired from service on the 1st June, 1919, and it is only befitting that in a report like the present one reference should be made to the long, faithful, and conscientious service he has rendered in that post. He was appointed Director of the Observatory early in 1896 in succession to Mr. Charles Chambers, F. R. S., who died suddenly about that time. A lucid account of the record of the work that he has put in at the Colaba and Alibag Observatories will be found in the last year's report, where Dr. Moos has given a life history of the institution from its very beginning up to the time of his retirement. Dr. Moos has a long list of valuable publications to his credit; for a description of the publications reference may again be made to the last year's report. He is a Doctor of Science of Edinburgh University, a Fellow of the Royal Society of Edinburgh, and a member of several European and Indian scientific societies. Dr. Moos made over charge to Mr. C. W. B. Normand, Imperial Meteorologist, who held the post up to the 30th June. After that date the Observatory was in charge of Mr. M. V. Unakar, the first assistant in the Observatory, who officiated in the post pending the appointment of a new permanent Director. He held the post right through to the end of the year under report."

29. *Corrigenda, Chree's article "Corrections for Non-Cyclic Change."* On page 7 of the March, 1920, issue, line 25, "At hour $n - r$ (or $n + r$)" should read "At hour $12 - r$ (or $12 + r$)"; line 18 from the bottom, "11 at 11h," should read "11 at 1h,". In connection with the latter the author suggests it might have been clearer to have said: "Add to the corrections obtained for N : 1 at 11h and 13h, 2 at 10h and 14h . . . 11 at 1h and 23h, and 12 at 0h and 24h."

LIST OF RECENT PUBLICATIONS

A. Terrestrial and Cosmical Magnetism.

Agincourt and Meanook Observatories. Magnetic disturbances, Jan., Feb., March, 1920. Toronto, J. R. Astr. Soc. Can., v. 14, No. 4, May, 1920 (169-170).

Agincourt and Meanook Observatories. Magnetic disturbances, April-May, 1920. Toronto, J. R. Astr. Soc. Can., v. 14, No. 5, June, 1920 (214).

Bombay and Alibag Observatories. Report of the Director, Bombay and Alibag Observatories, for the year ending December 31, 1919. (T. K. Chinmayanandam, Director.) Bombay, Govt. Central Press, 1920 (10). 33 cm.

Cortie, A. L. The great sun-spot group and the magnetic storm, 1920 March 22-23. London, Mon. Not. R. Astr. Soc., v. 80, No. 6, Apr., 1920 (574-578 with 1 pl.).

Dodge, G. B. Magnetic results, 1918-1919 [in Canada]. Toronto, J. R. Astr. Soc. Can., v. 14, No. 6, July, 1920 (242-247).

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Herbert, W. H. Deviation of magnetic declination in Western Canada. Toronto, J. R. Astr. Soc. Can., v. 14, No. 6, July, 1920 (239-241).

Hermant, A. Levé magnétique de la Belgique au 1er janvier 1913. Extr. Bruxelles, Ann. Obs. Belgique, N. S., Physique du Globe, T. 6, 1919 (122 avec 4 pls.). 32 cm.

India, Survey of. Records of the Survey of India. Vol. XIII (Supplementary to General Report 1917-18). Annual reports of parties and offices 1917-18. Prepared under the direction of Colonel C. H. D. Ryder, C. I. E., D. S. O., R. E., Offg. Surveyor General of India. Dehra Dun, Office of the Trigonometrical Survey, 1919 (123 with illus. and maps). 35 cm. [Pp. 65-84 contain account of No. 18 Party (Magnetic Survey) and the mean values of the magnetic elements at the various observatories for 1917.]

Krogness, O. The importance of obtaining magnetic registrations from a comparatively close net of stations in the Polar Regions. Kristiania, Geofysiske Publikationer, v. 1, No. 4, 1920 (5-18).

Meisenhelter, N. A cruise on the brigantine *Carnegie*. The National Marine, New York, N. Y., v. 15, No. 6, June, 1920 (10-18 with illus.).

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Schueck, A. Der Kompass. III. Nachtrag zu Der Kompass II. Armierte Magnetsteine (natürliche Magnete) mit verzierter Fassung. Fortsetzung der Tafeln zu IIa. Tafel 80-88 und Verzeichnis derselben. Hamburg, Druck von Kruse & Freiherr, 1918 (34 mit 9 Tafeln). 36 cm.

Terrestrial Magnetism
and
Atmospheric Electricity

VOLUME XXV DECEMBER, 1920 NUMBER 4

ON VERTICAL ELECTRIC CURRENTS AND THE RELATION BETWEEN TERRESTRIAL MAGNETISM AND ATMOSPHERIC ELECTRICITY.[1]

By LOUIS A. BAUER.

1. To what extent the magnetic forces as observed on the surface of the Earth can be referred to a potential, is a subject of paramount interest. The solution of the problem is of great importance, both as regards the constitution of the so-called permanent magnetic field of the Earth and the systems giving rise to the manifold variations to which the terrestrial magnetic field is continually subject.

2. Any electric currents circulating above or below the Earth's surface in concentric layers, i. e., parallel to the surface, will give rise to magnetic forces which may be represented by a potential. Electric currents, on the other hand, cutting the Earth's surface, produce, in general, a mixed magnetic system: the horizontal components of such currents give rise to a magnetic potential, whereas, the vertical components cause magnetic forces which cannot be referred to a potential. As is well known, the test of the existence of a potential is the vanishing of the line-integral of the magnetic force taken around a closed curve, or circuit, on the Earth's surface. If the line-integral does not vanish and its departure from zero cannot be explained by error of observation, or local magnetic disturbances in the region of the circuit, then the existence of a non-potential is revealed; from the magnitude and sign of the integral we may then determine the strength and direction of the electric currents passing perpendicularly through the surface of the region enclosed by the circuit.

[1]Presented at the Chicago meeting of the American Physical Society, December 30, 1920.

The Earth's Permanent Magnetic Field.

3. Gauss was the first to apply a test for determining whether the Earth's permanent magnetic field is caused by a potential. He computed the line-integral around a triangular area, at the vertices of which the magnetic elements had been observed, and found that it approximately vanished.[2] He thence made his well-known spherical harmonic analysis of the Earth's magnetic field, as based on the potential theory, and obtained a fairly close representation of the magnetic data available to him at the time. From Gauss's analysis it appeared that the Earth's field could be regarded as arising practically entirely from magnetic and electric systems below the Earth's surface.

4. The most complete mathematical analysis we have had in recent times was that by Adolf Schmidt on the basis of the Neumayer magnetic charts of 1885. His analysis was based on the most general assumptions possible, namely, that the Earth's total permanent magnetic field is to be ascribed to the following: (1) a magnetic potential, V_i, caused by the systems below the Earth's surface; (2) a magnetic potential, V_e, caused by systems above the Earth's surface; and (3) a non-potential part, N. Schmidt found that V_i contributed about 95 percent of the total field; V_e and N together, produced the remainder. He further found that the average current-density of the vertical currents giving rise to the portion N was, on the average, for the entire Earth's surface, regardless of direction, one-sixth of an ampere per sq. km.; such vertical currents would account for about 2 or 3 percent of the Earth's total magnetic field.

5. Shortly after the announcement of Schmidt's results, Rücker[3] computed the line-integrals for certain circuits in Great Britain on the basis of data resulting from the Rücker and Thorpe Magnetic Survey, but failed to find vertical currents of the strength and direction indicated by Schmidt's analysis. Schmidt's currents were about 50,000 times stronger than the vertical currents measured generally with atmospheric-electric interuments. Owing to these difficulties, Schmidt was finally led to doubt the validity of his general conclusion and to express the opinion that possibly his result was to be ascribed to systematic errors in the magnetic charts.[4]

[2] Allgemeine Theorie des Erdmagnetismus, p. 13; *Resultate aus den Beobachtungen des magnetischen Vereins im Jahre 1838*, Leipzig, 1839.

[3] *Terr. Mag.* vol. 2, 1896, p. 84.

[4] Der magnetische Zustand der Erde, 1885, p. 27. See also "Mitteilungen über eine neue Berechnung des erdmagnetischen Potentials," *Abh. d. II. Cl. d. k. Muenchen. Ak. d. Wiss. XIX Bd., I. Abth.*

6. Since in evaluating N it is necessary in the analysis to introduce some assumptions, I decided to investigate the question as to the existence of vertical currents by the direct method of Gauss, namely, of computing line-integrals, which method can be immediately applied to the available magnetic data without first making a laborious mathematical analysis of the total field. In future analyses it may be found advantageous to attempt evaluating first possible vertical currents, and then correct the magnetic data for their effect before undertaking the mathematical analysis.

7. My first investigation consisted in computing the line-integrals, taking as circuits of the Earth parallels of latitude and using approximate data scaled from Neumayer's published magnetic charts for 1885; a brief summary was submitted to the committee on grants of the American Association for the Advancement of Science at the meeting in 1895. With the aid of a small grant received from the committee, I was enabled to obtain, through Schmidt's courtesy, a transcript of the Neumayer data used by him in his analysis and thus to extend my investigation, the results of which were published in 1897.[5] The method of computation was such as to eliminate, or reduce to a minimum, the effect of systematic errors in the charts from which the magnetic data had been derived. A rather interesting and suggestive distribution of vertical electric currents was found for the region investigated from parallel 60° North to parallel 60° South. The average intensity of the vertical currents per sq. km. turned out to be about one-tenth of an ampere, which, while somewhat smaller than Schmidt's value, was still about 35,000 times that obtained from usual atmospheric-electric measurements.

8. In 1904, I published the results of a second investigation[6] concerning vertical electric currents, the prime purpose of which was to obtain some idea as to the magnitude of the magnetic quantities involved in order that plans for tests to determine the existence of a potential might be included in the contemplated magnetic survey of the Earth under the auspices of the Carnegie Institution of Washington. Use was made of all the available magnetic charts to date: Sabine's of 1840-45, Creak's of 1880, and Neumayer's of 1885. Again latitudinal circuits were made from 60°N and 60°S. The combined results from the three charts were practically the same as those derived in my 1897 paper on the

[5] *Terr. Mag.* vol. 2, 1897, pp. 11-22.

[6] *Terr. Mag.* vol. 9, 1904, pp. 116-129.

basis of the Neumayer charts alone; the average current-density for the region 45°N to 45°S, over which the results appeared most certain, was one-thirtieth of an ampere per sq. km.—still about 11,000 times that found in atmospheric electricity.

9. It was shown in the 1904 paper how results concerning vertical currents could be derived from declination charts[7] alone. A positive electric current passing, for example, from the air through the Earth's surface, in accordance with Ampere's rule, will deflect the north end of a magnetic needle to the West; a reversed current, on the other hand, would deflect the needle to the East. The distribution and intensity of the vertical currents appeared to be such that for certain regions or parallels the needle, for long stretches, might have a deflection in the same direction amounting to 0°.2 and more—a quantity readily measurable even in ocean work. In mapping out the cruises of the *Galilee* and the *Carnegie* full consideration was given to obtaining closed circuits as frequently as possible, in various regions and under different conditions, in order that sometime adequate tests might be made with regard to the existence of vertical currents having appreciable magnetic effects.

10. On April 23, 1908, I presented at the Washington meeting of the American Physical Society the results of a third investigation on vertical currents, dependent this time upon the 1905 magnetic charts for the United States as constructed by me on the basis of the detailed magnetic survey carried out under my direction by the United States Coast and Geodetic Survey. The line-integrals were computed for circuits around and within the United States. Once more vertical currents were indicated that apparently could not be ascribed wholly to observational error. As their average strength, as seen later, was again of an order 10,000 times that of atmospheric electricity I refrained from publishing the results, although they were based upon the largest land area for which a detailed and carefully-conducted magnetic survey had been made.

11. Others have computed line-integrals, or surface-integrals, of the magnetic force over more or less restricted land regions, but there has been no general consensus of opinion that the question of the existence of vertical currents producing appreciable effects in terrestrial magnetism was definitely settled, one way or the other. It is doubtful whether any reliable results can be

[7] *Idem*, pp. 123-126.

obtained unless the integrals are taken over very extensive areas and unless a method of computation is used which eliminates adequately the effects from local and regional disturbances. My own preference is to deal with the directly-observed magnetic quantities, rather than with adjusted ones. It is quite possible that some of the results obtained by others may be merely the products of adjustment, or as a necessary consequence of the attempt to make the observed quantities fit some particular pattern.

12. Gockel in 1912 published a paper in which he showed interesting correlations between the air-earth currents of atmospheric electricity, the diurnal variations of the Earth's magnetism, and the electric currents in the Earth's crust.[8] He made no attempt to determine the strength of the vertical current necessary to produce the magnetic variations, but it can readily be shown that it would have to be several thousand times that revealed by the diurnal variations of the atmospheric-electric current. (See paragraph 40.)

13. And now we come to the results of the present paper. Preparatory to the construction of world magnetic charts and the mathematical analysis of the Earth as based upon the accumulated data, a variety of investigations are under way in the Department of Terrestrial Magnetism. One of these researches concerns itself with the computation of the line-integrals, with all possible accuracy and refinement, for a number of circuits in various regions of the globe. To compute these integrals entails considerable labor which, in the end, may prove not to have been wholly necessary. It was, therefore, deemed desirable to make first a reconnaissance and repeat my former computations of line-integrals along latitudinal circuits, using this time magnetic charts, which while not representative of all the available data of the Department of Terrestrial Magnetism are close approximations thereto, namely, the declination chart for 1917 of the British Admiralty and the declination and horizontal-intensity charts for 1920 of the United States Hydrographic Office. These charts are based upon the most recent magnetic data as furnished chiefly by the Department of Terrestrial Magnetism. In brief, *while the present results are not yet as accurate as they ultimately may be, they are based on far superior data than heretofore available.*

14. If W be the total work done by a unit magnetic pole in

[8] *Terr. Mag.*, vol. 17, 1912, pp. 1-19.

moving around a closed curve on the Earth's surface, H, the horizontal component of the magnetic force against which the pole is being moved, ϵ the angle H makes with the tangent to the path traversed, ds the curve-element, I, the intensity in electromagnetic units of any electric currents which may pass vertically through the surface of the enclosed area, then is

$$W = \int_0^0 H \cos \epsilon . ds = 4\pi I \qquad (1)$$

Traversing the circuit in an anticlockwise direction, a positive value of the integral implies upward positive electric currents, i. e., earth-air currents, and a negative value implies downward positive currents, or air-earth currents, such as believed generally indicated by atmospheric-electric observations.

15. Choosing parallels of latitude for our circuits and going around the Earth in an eastward direction, $H \cos \epsilon$ becomes the component Y, directed positive to the East. We have

$$W = \int_0^{2\pi} Y ds = 4\pi I \qquad (2)$$

Experience has shown that a sufficiently close approximation to the integral is obtained by summing up the value of Y at longitude intervals, $d\lambda$, of 5°, or even 10°. Setting $ds = 2\pi R \sin u . \frac{d\lambda}{360}$ where u is the co-latitude of the parallel along which the circuit is made and R is the Earth's mean radius $= 6.37 \times 10^8$ cm., and since $\frac{d\lambda}{360} \sum_0^{2\pi} Y = Y_m$, the mean value of Y along the parallel, we have for I expressed in amperes:

$$I = 5R \sin u . Y_m \qquad (3)$$

I is the resultant quantity of electricity passing in a second of time perpendicularly through the zone from the north geographical pole to the parallel of latitude around which the complete circuit of the Earth is made. If i is the average strength per unit area of the resultant current passing perpendicularly per second through the surface of the zone bounded by the two parallels whose co-latitudes are u_1 and u_2, $u_2 > u_1$, and A is the area of the zone,

$$i = \frac{I_2 - I_1}{A} \qquad (4)$$

in which $A = 2\pi R^2 (\cos u_1 - \cos u_2)$.

16. Table 1 contains the results regarding vertical electric currents computed with the aid of the preliminary magnetic data as already explained. *The results are subject to some modifications in detail, when the more elaborate computations have been completed;* however, the general conclusions to be drawn from the results may not be materially changed. The present results confirm in general those given in my 1897 and 1904 papers (footnote references 5 and 6).

TABLE 1.—*Residual vertical currents from preliminary magnetic data for 1920.*
(A + sign means upward positive current.)

Zone (N. Hem.)	I (10^4 Amp.)	i (10^{-3}A/km²)	Zone (S. Hem.)	I (10^4 Amp.)	i (10^{-3}A/km²)	Zone (N. and S.)	I (10^4 Amp.)	i (10^{-3}A/km²)
N. P. to 50°N	+127	+21	S. P. to 50°S	+109	+18	Pole to 50°	+118	+20
50°N to 45°N	+ 67	+45	50°S to 45°S	+ 51	+34	50° to 45°	+ 59	+40
45°N to 40°N	− 9	− 6	45°S to 40°S	− 77	−47	45° to 40°	− 43	−26
40°N to 35°N	+ 32	+18	40°S to 35°S	− 39	−22	40° to 35°	− 3	− 2
35°N to 30°N	+ 15	+ 8	35°S to 30°S	− 58	−31	35° to 30°	− 21	−11
30°N to 25°N	− 56	−29	30°S to 25°S	+ 37	+19	30° to 25°	− 10	− 5
25°N to 20°N	− 77	−37	25°S to 20°S	+120	+58	25° to 20°	+ 21	+10
20°N to 15°N	− 41	−19	20°S to 15°S	+ 86	+41	20° to 15°	+ 22	+11
15°N to 10°N	− 71	−33	15°S to 10°S	− 90	−41	15° to 10°	− 80	−37
10°N to 5°N	−117	−53	10°S to 5°S	+ 30	+14	10° to 5°	− 44	−20
5°N to Equ.	− 39	−18	5°S to Equ.	+ 20	+ 9	5° to Equ.	− 10	− 5

17. To illustrate the figures in Table 1: Through the zone from the North Pole to parallel 50° N, there is a resultant total upward positive current, I, of $+127\times10^4$ amperes, giving an average current-density, i, of $+21\times10^{-3}$ ampere per sq. km.; for the south polar cap from the South Pole to 50° S, there is a resultant total upward positive current of $+109\times10^4$ amperes, the average current density being $+18\times10^{-3}$ ampere per sq. km.; on the average, for the two polar caps the resultant upward positive current is $+118\times10^4$ amperes, and the average current-density, $+20\times10^{-3}$ ampere per sq. km. For the zone bounded by the two parallels, 30° N and 25° N, there is a resultant total downward positive current of -56×10^4 amperes, giving an average current-density of -29×10^{-3} ampere per sq. km.

18. Figure 1 shows the average distribution along the mean geographical meridian of the current-density, i, as given for the various zones in Table 1. The full curve (P) shows the preliminary values of i for 1920; the dotted curve (A) shows the approximate values as obtained from my previous investigation, which was dependent upon the approximate magnetic charts for 1842, 1880, and 1885.[9] An upward arrow indicates an upward positive cur-

[9] *Terr. Mag.*, vol. 9, 1904, Table 1, p. 121.

rent, or downward negative current; a downward arrow indicates the reverse. It will be seen that the two curves *P* and *A* show considerable similarity, the only marked departure arising from the differences in the line-integrals for parallel 30° S. The parallel 30° S passes through the region of the Indian Ocean where the secular variation is both large in amount and varies rapidly with geographic location; it was in this region that the *Carnegie* observations revealed some of the largest errors in the magnetic charts used at the time.

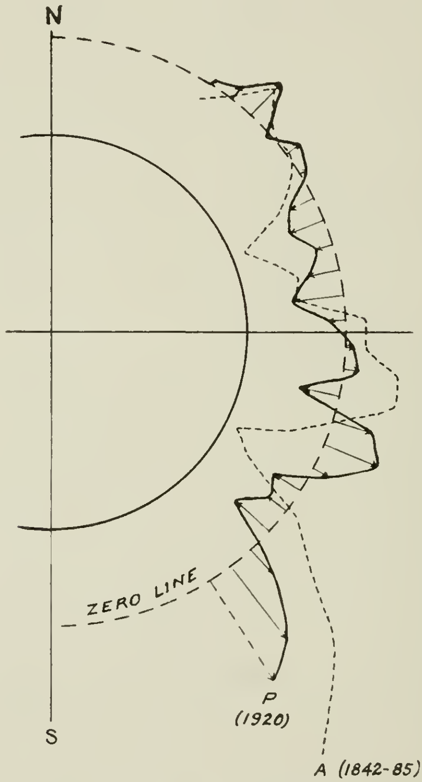

Fig. 1.—Distribution of Vertical Current-Densities Along a Mean Meridian.
[See Table 1 and Paragraph 18.]

19. It should not be assumed of course that Fig. 1 represents the true meridional distribution for any one meridian. For example, it should not be assumed that everywhere in the zone between parallels 30° N and 25° N, there is a current-density of

-29×10^{-3} ampere per sq. km.; there may be regions in the zone where the resultant positive current is plus, or upward, and in other regions, minus, or downward. The quantities in Table 1, or as shown by Fig. 1, represent only the average excess of upward and downward currents for the zone considered.

20. The average resultant current-density for the mean meridian and for the region 50° N to 50° S, is about one-thirtyfifth (29×10^{-3}) of an ampere per sq. km.; from the previous investigation I had found on the basis of the magnetic charts for 1842-1885 and for the region 45° N to 45° S, an average resultant current-density of about one-thirtieth of an ampere per sq. km.[10] However, the average plus i or average minus i, taken separately and as found from line-integrals around ten-degree quadrilaterals for the region 60° N to 60° S, turns out to be as much as one-eighth of an ampere per sq. km.; as already stated in paragraph 4, Schmidt had found from his analysis of the 1885 magnetic charts for the average current-density, whether plus or minus, one-sixth of an ampere per sq. km.

21. Combining the results for corresponding parallels north and south of the equator in order to eliminate to some extent possible asymmetries caused by the asymmetrical magnetization of the earth, or by the distribution of land and water and other physical agencies, the results for i given in the last column of Table 1 are obtained. It will be seen that in the lower latitudes, on the average, downward currents, or positive air-earth currents, prevail, whereas in the high-latitude zones upward positive currents, or earth-air currents, predominate. It is of interest to note here that the average current-density of the downward positive current for the two hemispheres is apparently largest in the zone 10° to 15°. (Cf. paragraph 33.)

22. Table 2 would seem to show the following general facts:

TABLE 2.—*General distribution of vertical currents according preliminary results for 1920.*

Zone	I (10^4 Amperes)	i (10^{-3} Amp./km.^{2})
North Pole to 45° North	+194	+26
45° North to 45° South	−354	−10
45° South to South Pole	+160	+21

[10] *Terr. Mag.*, vol. 9, 1904, p. 127.

In the polar caps down to about parallel 45°, the resultant vertical currents are on the average upward for positive currents and downward for negative currents, the average current-density being about 24×10^{-3} ampere per sq. km.; in the region of the Earth between 45° N to 45° S, the resultant vertical currents are on the average downward for positive currents and upward for negative currents, the average current-density being about 10×10^{-3} ampere per sq. km. *If then we speak in terms of negative currents, we apparently have, on the average, negative electricity streaming into the Earth in the polar regions, or regions of pronounced polar lights, and streaming out into the air in lower latitudes. Or, we may say also that we apparently have, on the average, negative electricity streaming into the Earth in polar regions, and positive electricity streaming into the Earth in lower latitudes.*

23. It has already been explained in paragraph 19 that the results in Tables 1 and 2 merely show the resultant currents, or the difference between the total upward and downward positive currents over the region considered. In order to make some tests as to the manner of distribution of the upward and downward currents, the average currents over quadrilaterals bounded by two parallels 10° apart and two meridians, also 10° apart, were derived for the entire region from 60° N to 60° S. As a preliminary result, it was found that, on the average, the positive current was upward over the ocean quadrilaterals and the quadrilaterals of low barometric pressure, and downward over the land quadrilaterals and the quadrilaterals of high pressure. However, to disentangle any effects of distribution of land and water from any effects of low and high barometric pressure, or from the variations in the vertical electric current with latitude, will require further investigation, and, accordingly, no definite conclusion is drawn at present. Acknowledgement is here made of effective computing assistance received from Messrs. C. C. Ennis, C. R. Duvall, and G. H. Keulegan.

24. One of the most interesting circuits around which to compute the line-integral of the magnetic force is that of the *Carnegie's* sub-antarctic cruise of 17,084 nautical miles. Leaving Lyttleton, New Zealand, December 6, 1915, the *Carnegie* returned there on April 1, 1916, after a continuous voyage of 118 days, except for a stop of two days at King Edward Cove, South Georgia Island. The circumnavigation of the Earth was made between the parallels about 40° S and 60° S, the average parallel being about 52° S; the

average day's run was 145 nautical miles. Declinations were generally observed twice a day and horizontal intensities and inclinations, once a day. A preliminary computation of the line-integral was made by Messrs. W. J. Peters and C. R. Duvall, of the Department of Terrestrial Magnetism. They found apparently a total resultant negative current, I, passing from the air perpendicularly through the surface of the zone, from the South Pole down to the circuit, of 80×10^4 amperes, which corresponds to an average current-density of 0.016 ampere per sq. km. Table 1 shows an average current-density for the zone from the South Pole to parallel 50° S, of 0.018 ampere per sq. km., for upward positive currents, or for downward negative currents. Results from other line-integrals will soon become available, computed with all possible accuracy.

Results for Vertical Currents in the United States.

(Abstract.)

25. The 1908 investigation, already referred to in paragraph 10, depended upon the 1905 magnetic charts for the United States. The average results of the line-integrals around and within the area between the meridians 77° W and 117° W and the parallels 33° N to 49° N was a downward positive current of 26×10^{-3} ampere per sq. km.

26. The computations have since been repeated with the aid of the 1915 magnetic charts for the United States which are dependent not only upon the extensive data available for the 1905 charts, but also upon the additional observations made by the United States Coast and Geodetic Survey since 1905. It may be remarked further that, while the 1905 charts were constructed under the writer's direction, those for 1915 were constructed independently under the direction of Mr. D. L. Hazard. The average result of the computations by the Department of Terrestrial Magnetism of the line-integrals for 1915 around and within the area enclosed by the meridians 75° W and 117°.5 W and the parallels 30° N and 50° N was a downward positive current of 33×10^{-3} ampere per sq. km. The average result from the line-integrals about and within the area in the middle part of the United States bounded by parallels 35° N to 45° N and the meridians 80° W to 120° W, was a downward positive current of 32×10^{-3} ampere per sq. km.

27. It may be remarked that, before the magnetic charts for

1905 and 1915 were constructed, all observations were referred to mean of day and to the mean date, using for this purpose the data from the magnetic observatories and from the numerous repeat stations.

Giving the 1915 result double weight, it is apparently found that the 1905 and 1915 magnetic charts for the United States show, on the average, downward positive currents, or upward negative currents, the average current-density over the greater part of the United States being about 31×10^{-3} ampere per sq. km.

How the strength of the vertical current varies over the United States with latitude and longitude, is the subject of a separate investigation. There would seem to be a tendency in certain regions towards a zero value of the current or even reversal of current. Turning to Tables 1 and 2, and Fig. 1, it will be seen that the United States in part may be in the transition region where the upward positive currents of northerly latitudes pass over to downward positive currents of lower latitudes.

On the Relation between Terrestrial Magnetism and Atmospheric Electricity.

28. Let i_m be the strength in amperes per sq. km. of the vertical currents as found from the line-integrals of the magnetic force, and let i_a be the value resulting from atmosperic-electric measurements. We have the following values of these quantities:

$i_m = 2.9 \times 10^{-2}$ (average value along a mean meridian, from 50°N to 50°S, regardless of sign)

$i_a = 3 \times 10^{-6}$ (approximate average value from land and ocean observations).

Hence, approximately

$$i_m = 10^4 \times i_a = f.\, i_a \tag{5}$$

It is thus seen that the average result from the magnetic observations is about 10,000 times that from the atmospheric-electric observations; since according to paragraph 20 the average $+i_m$, or $-i_m$, taken separately, may be as much as 13×10^{-2}, the factor f may at places be as high as 40,000. But the large value of f presents not the only difficulty in attempting to harmonize the results from the two different sets of measurements.

29. It is generally concluded from the atmospheric-electric results that all over the Earth there is a downward positive current, called the "air-earth current of atmospheric electricity." How-

ever, the vertical currents from the magnetic work, as shown in Tables 1 and 2, and Fig. 1, while, on the average, downward positive in lower latitudes, appear to be, on the average, upward positive in higher latitudes. The integral of the vertical currents from terrestrial magnetism, if taken over the entire Earth, may be zero, the downward currents being balanced by the upward ones. On the other hand, the conclusion usually drawn from the atmospheric-electric observations is that there is a uniform resultant negative charge over the whole Earth, which, because of the conductivity of the air, requires for its maintenance, a continuous replenishing current of about 1,000 amperes. Hence, the discord between the magnetic and electric results arises both from respective magnitudes of the vertical currents and from the variation in direction over the Earth in the case of the former, and the supposed constancy in direction, during normal conditions, in the case of the latter (the atmospheric-electric conduction current).

30. Unfortunately we are not able at present to make an exhaustive examination into the question whether there are sufficient data to indicate that the atmospheric-electric current, i_a, is, indeed, *everywhere* downward positive during fine weather. Latterly observers often fail to state, when publishing potential-gradient observations, whether they have actually made a test of the sign or direction. In view of the very large and rapid fluctuations in the atmospheric-electric current, which take place during the day, and the well-known reversals of current often occurring during cloudy or rainy weather, we must not, of course, expect always complete accord between the vertical currents from the magnetic observations and those from the atmospheric-electric observations.

31. It may be pointed out that the value of the surface density, σ, of the Earth's assumed negative charge, as deduced from potential-gradient measurements, is subject to a geographical variation of at least 50 per cent; the average value is about -3×10^{-4} E. S. U. At Kew Observatory, England, σ is about three times the average value, and according to the observations made at Sobral, Brazil, by Mr. Andrew Thomson of the Department of Terrestrial Magnetism, May-June, 1919, it is about one-sixth of the average value. When σ is subject to such large geographic variations, the question may be raised whether the surface charge may not at some places practically vanish and at other places have reversed sign, even under normal conditions. It may further be recalled that the

results of measurements of the horizontal electric currents in the Earth's crust, have not yet been brought into harmony, quantitatively, with such horizontal currents as might be indicated by variations in the values of σ.

32. The average current, i_m, from the line-integrals in the United States was found to be downward positive and 3.1×10^{-2} ampere per sq. km.; the results of the atmospheric-electric observations being made at Washington by the Department of Terrestrial Magnetism, give a value of i_a of the downward positive current about 3×10^{-6} ampere per sq. km. The average result from Rücker's own line-integrals in Great Britain from the 1886 and 1891 magnetic surveys indicated a downward positive current value of 8×10^{-3} ampere per sq. km.;[11] the atmospheric-electric observations at Kew give on an average a positive air-earth current of about 1×10^{-6} ampere per sq. km., or about one-ten thousandth that from Rücker's integrals. For two regions, the United States and Great Britain, for which we may make *preliminary* comparisons, the direction of the vertical currents from the two classes of work agree at least as far as direction of current is concerned, but the outstanding numerical factor f is about 10^4.

33. It is also of interest to record here that, according to Dr. Mauchly's reductions, the atmospheric-electric observations, made on cruises IV and V of the *Carnegie* in the Pacific Ocean, show that the current-density, reduced to mean of day, has a maximum value of about 3.3×10^{-6} ampere per sq. km. in the zones 20° N to 20° S; the current-density then in general decreases until about parallel 47°, when the value is but 1.9×10^{-6} ampere per sq. km. The law of variation with latitude in the values of i_a for the Pacific Ocean runs, in general, parallel with that shown by the values of i_m, given in the last column of Table 1. (See also paragraph 21.)

34. If there is any hope of harmonizing in all parts of the Earth the results from terrestrial magnetism and atmospheric electricity, at least in so far as direction of current is concerned, then a new aspect would be given the problem of the maintenance of the Earth's negative charge. Though this problem has received the attention of most eminent investigators, there is still no generally accepted theory. The difficulty consists in finding an adequate cause for the continual replenishing of a negative charge of the Earth of the required amount; because of the conductivity

[11] *Terr. Mag.*, vol. 1, 1896, p. 84.

of the air, the Earth's charge would be practically dissipated in about 10 minutes, unless the supply were renewed. If, on the other hand, the sign of the *A.E.* current, i_a, undergoes changes over the Earth such as does the i_m current, then the problem of the maintenance of an Earth-charge may possibly be simplified, as the total charge over the Earth may turn out to be practically zero.

35. It is not to be understood that any definite assertions are being made; the desire is merely to call renewed attention to the need of determining unquestionably the direction of the *A.E.* current during normal weather in all parts of the Earth. It should also be stated that it may easily turn out that the positive upward current (or negative downward) in the polar regions, as indicated by the magnetic line-integrals, may be concentrated over rather restricted areas near the magnetic poles. The density of the inward, or downward, negative currents near these poles may be sufficient so as to make their total equal the total outward, or upward, negative currents prevailing over the very much larger portion of the Earth.

36. The outstanding discrepancy, however, between the magnetic and electric results is the large numerical factor, f. Though we are investigating various hypotheses, we have no explanation at present to offer, other than that the usual instrumental appliances for atmospheric-electric observations are designed to detect but comparatively slowly-moving charged particles, such as ions. A corpuscular current, of sufficiently high penetrability, as to get through the atmosphere and down to the Earth, or *vice versa*, might not be measured, or at least not completely, by ordinary electric methods. Another outstanding puzzle of atmospheric-electricity, the so-called "penetrating radiation," seems to indicate that something of a highly penetrating character does actually get through the atmosphere and down to the surface of the Earth. In brief, it may happen that the current density as deduced from magnetic measurements would differ from that deduced from electrostatic measurements. If the two sets of currents show at least a qualitative relationship, as they apparently do, then either both are to be referred to the same cause, or one, the i_a current, may, perhaps, be a secondary effect brought about as the i_m current passes through the atmosphere into the Earth.

Concluding Remarks.

37. To account for the strength of the vertical currents apparently revealed by magnetic observations, it would seem that we must either assume operating agencies of exceedingly high penetrability, or must look for other causes, which, doubtless will again necessitate postulating agencies appearing improbable on the basis of present knowledge. The question naturally arises as to what reliance may be put upon the results from the magnetic line-integrals, other than the evidence we have already given.

38. Variations in the vertical currents, which apparently took place during the solar eclipse of May 29, 1919, will be described in a future paper. In addition the interesting question has been seriously raised in recent years whether the agencies causing the well-known diurnal variations of the Earth's magnetism have in their entirety a potential. Dr. Annie van Vleuten, who has made an extensive investigation of the question, reached a negative conclusion; it would seem necessary to assume that vertical currents are responsible, partly at least, for the diurnal variation[19] of the Earth's magnetism.

39. On the basis of Dr. van Vleuten's derived coefficients for the diurnal variation of terrestrial magnetism, I have computed the current-densities, $\triangle i_m$, for a station situated on the parallel of latitude 38° 44′ N and for the mean of the summer months (April-September), 1906-1908. As a close approximation, it is generally assumed that the diurnal variation of the Earth's magnetism is the same for all stations along the same parallel of latitude; the same is assumed with regard to the vertical currents disclosed by magnetic diurnal-variation observations. Hence, while the latitude chosen is that of the Cheltenham Magnetic Observatory in Maryland, we may with fair approximation for the reasons stated, apply our computed quantities to any point, let us call it "Magnetism", on the designated parallel. Curve 3 of Fig. 2 shows the diurnal variation, $\triangle i_m$, of the vertical currents of terrestrial magnetism. For comparison there have been added the summer diurnal-variation curves, $\triangle i_a$, of the atmospheric-electric currents, first

[19]Do the forces causing the diurnal variation of terrestrial magnetism possess a potential? *K. Ak. van Wet. Amsterdam, 26*, pp. 297-299, 1917. [For fuller publication see *Mededeelingen en Verhandelingen No. 23*, published as Bulletin No. 102 of the K. Nederlandsch Meteorologisch Instituut, Utrecht, 1917. There are unfortunately a number of typographical errors in this valuable publication. The interested reader should use the coefficients as given on page 89 in preference to those on page 111. As the formulæ, for which Dr. van Vleuten's coefficients apply, are to be considered in the nature of more or less empirical ones, it is not admissible to make use of them much beyond the region of the data used in their establishment (about 60° N to 15° S). Accordingly for this reason as well as others, Adolf Schmidt's concluding arguments (*Physik. Zeitschr*, XIX, 1918, 349-355) against the correctness of Dr. van Vleuten's conclusion do not appear legitimate.—*L.A.B.*]

(Curve 1) as shown by Dr. Dorno's observations[13] at the Alpine station, Davos (latitude 46° 48′ N; longitude, 9° 49′ E; altitude

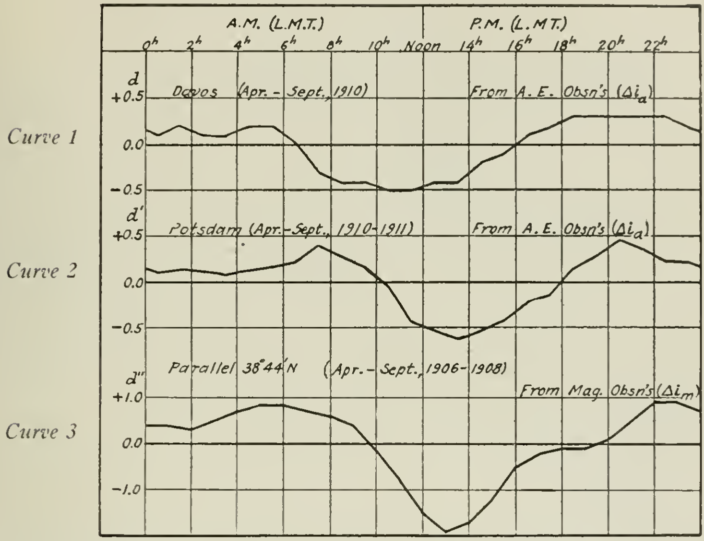

FIG. 2. SUMMER DIURNAL VARIATION OF AIR-EARTH CURRENT-DENSITY OF ATMOSPHERIC-ELECTRICITY (CURVES 1 AND 2) COMPARED WITH DIURNAL VARIATION OF VERTICAL CURRENT-DENSITY OF TERRESTRIAL MAGNETISM (CURVE 3).

[Note the remarkable similarity of Curve 3 with Curves 1 and 2. Plus value of ordinate means a value of the current-density higher than the mean value for the day (24 hours). Scale of ordinates: For Curves 1 and 2, $d = d' = 10^{-6}$ Amp/km^2; for Curve 3, $d'' = 10^{-3}$ Amp/km^2. See paragraph 39.]

above sea-level, 1,560 meters), and secondly (Curve 2) at the Potsdam Observatory (52° 23′ N; 13° 04′ E; altitude above sea-level, 86 meters). The three curves are plotted according to local mean time; it will be seen that they show a good general agreement. As the curves are plotted, a minus ordinate indicates a value of the positive air-earth current-density less than its mean daily value. Accordingly during the daytime (6 A. M. to 6 P. M.) both sets of currents, $\triangle i_a$ and $\triangle i_m$, unite in showing, on the average, a decreased positive downward current. During the night hours, on the average, the positive downward current is increased.

At some other occasion the matters in this paragraph will be discussed more fully. From various preliminary investigations of magnetic storm-effects which I have made, it also seemed as though some of the observed effects would have to be ascribed to vertical currents.

[13] *Studie ueber Licht und Luft des Hochgebirges*, table 78, p. 138. Braunschweig, 1911.

40. Table 3 contains the chief facts shown in Fig. 2. We see that:

TABLE 3.—*Diurnal variation of vertical currents for summer months (April-September).*

[Unit 10^{-6} Amp./km.^{2}; i=current-density; $\triangle i$=diurnal variation. A + sign means a greater value than daily mean.]

Station	Curve	Obser-vations	Current-Density, i		Average $\triangle i$		
			Daily Mean	Daily Range	Day Hours	Night Hrs.	24 Hours
Davos	1	At. Elect.	1.7	0.8	−0.24	+0.22	±0.3
Potsdam	2	At. Elect.	2.2	1.0	−0.15	+0.20	±0.3
Magnetism	3	Magnetic	3x10^4	2.8x10^3	−0.40x10^3	+0.43x10^3	±0.7x10^3

Average $\triangle i_a$ = about 0.15 i_a (Davos and Potsdam).

Average $\triangle i_m$ = about 0.02 i_m (Magnetism).

Average $\triangle i_m$ (Magnetism) = about 2×10^3 $\triangle i_a$ (Average, Davos and Potsdam).

41. The only approach in strength of the atmospheric-electric current to that of the vertical currents, shown apparently by magnetic observations, is in the case of shower-clouds. From C. T. R. Wilson's observations[14] it would appear that below a thunder-cloud, during lightning flashes, a current of electricity amounting to some amperes may pass from the atmosphere through a few square kilometers of the surface of the Earth. Under shower-clouds, the vertical current-density will, of course, be less than under thunder-clouds, still it would appear that it may be of the order of the vertical current-density from the magnetic line-integrals.

42. The questions raised in this paper, both with regards to terrestrial magnetism and atmospheric electricity, will receive further rigid investigation. It is believed that the present paper shows at least a *qualitative* relationship between certain phenomena of terrestrial magnetism and of atmospheric electricity.

[14] Investigations on lightning discharges and on the electric field of thunderstorms: *Phil. Trans.* Roy. Soc. of London, Ser. A, vol. 221, pp. 112-113.

THE AURORAL RADIANT FROM AMERICAN OBSERVATIONS OF 1915-1920.

CHARLES CLAYTON WYLIE.

Several auroral displays visible in recent years have shown well-defined coronae in the United States and Southern Canada. When streamers shoot up simultaneously from nearly every part of the horizon, they appear to meet in a rude crown of light known as the corona. Many series of observations have been made on coronae in Northern Europe, but in our latitudes aurorae are rarely of sufficient magnitude to show this feature. The recent brilliant displays have, therefore, offered Americans exceptional opportunity to observe the position of the center of the corona, or radiant of the auroral streamers.

Wilcke (Angot, *The Aurora Borealis*, p. 129), who studied the aurora between 1741 and 1774, found his observations indicated that the center of the corona is at the magnetic zenith. This result has been so confirmed that the majority of careful observers since his time have believed the streamers parallel to the magnetic lines of force, and the apparent convergence to the magnetic zenith the effect of perspective.

In Loomis's treatise on the aurora borealis (*Smithsonian Report*, 1865-66, p. 219) we read: "Now it is considered as established that the auroral streamers are luminous beams sensibly parallel to the direction of the dipping needle." Perhaps the most thorough work of the past twenty years is that of Störmer, whose successful application of photography to the study of the aurora is well known. The following is from his discussion of the results of his Bossekop work (Störmer, *Terrestrial Magnetism*, **20,** 11, 1915): "Now the electric corpuscles most probably descend into the atmosphere from without, along the magnetic lines of force, forming auroral rays. . . ."

Nevertheless, we still find some investigators doubting that the question is settled (Trowbridge, *Physical Review*, **11,** 483, 1918). Recently we even find (Thompson, *Proceedings National Academy of Sciences*, 1917, p. 1) a theory advanced which assumes that the

streamers are vertical, converging by perspective to the astronomical zenith.

Many descriptions of auroral displays apparently support Thompson's theory, convergence of the streamers toward the zenith being referred to in one way or another (Nutting, *Science*, **44**, 496, 1916). Such descriptions, however, probably mean only that a convergence toward a point somewhere overhead was noticed, not that any estimate of the position of that point was made. For example, C. C. Trowbridge examined some seventy descriptions of the great aurora of August 26, 1916. He found twenty referring to the convergence of the streamers, but aside from his own only one containing what he considered a real estimate of the position of the radiant.

In 1915-1920, six great auroræ have been observed in the United States and Southern Canada. Sixteen observations seemed to be reliable estimates of the position of the radiant. In five cases the observation was already reduced and the position of the corona compared with that of the magnetic zenith. For the reduction of the others, I have taken the longitude and the latitude of the place of observation from the American Ephemeris, or scaled the same from an atlas. The magnetic declination and dip, or the altitude and azimuth of the magnetic zenith, were scaled from a large chart published by the United States Coast and Geodetic Survey. I then transformed these elements to hour angle and declination of the magnetic zenith, and reduced the observed positions to hour angle and declination of the radiant of the streamers.

The following table gives the results. The column headed "Residual" gives the distance along a great circle from the observed position of the corona to the magnetic zenith.

No.	Date	Place	Observer	No. Estimates	Corona t	Corona δ	Mag. Zenith t	Mag. Zenith δ	Differences t	Differences δ	Residual
					°	°	°	°	°	°	°
1	1915, June 16	Williams Bay, Wisconsin.	Barnard	1	0.0	+23.0	+0.6	+25.7	—0.6	—2.7	2.8
2	1916, Aug. 26	Prince Ed. Is. Canada.	Trowbridge	1	—7.5	30.5	—7.3	32.6	—0.2	—2.1	2.1
3	1916, Aug. 26	Frankfort, Mich.	Stebbins	2	—2.4	30.2	+0.2	30.1	—2.6	+0.1	2.2
4	1917, Aug. 21	Georgian Bay, Canada.	Chant	1	+2.3	27.8	—2.0	30.9	+4.3	—3.1	4.9
5	1918, Mar. 7	Urbana, Ill.	Stebbins	3	+0.2	20.1	+1.1	21.2	—0.9	—1.1	1.4
6	1918, Mar. 7	Williams Bay, Wisconsin.	Barnard	2	+3.8	25.0	+0.6	25.7	+3.2	—0.7	3.0
7	1918, Apr. 2	Ottawa, Can.	Burling	4	+15.4	43.5	—3.8	31.4	+19.2	+12.1	(19.4)
8	1918, May 16	Wellesley, Mass.	Duncan	1	—1.6	27.0	—4.1	25.8	+2.5	+1.2	2.6
9	1920, Mar. 22	Wellesley, Mass.	Duncan	1	0.0	22.3	—4.1	25.8	+4.1	—3.5	5.1
10	1920, Mar. 22	Chestertown, Maryland.	Culp	1	—1.8	12.4	—2.6	20.0	+0.8	—7.6	7.6
11	1920, Mar. 22	Toronto, Ont., Canada.	Hunter	3	—1.0	26.2	—1.9	28.2	+0.9	—2.0	2.1
12	1920, Mar. 22	Detroit, Mich.	Kennedy	1	......	23.9	......	25.3	......	—1.4	......
13	1920, Mar. 22	Ann Arbor, Michigan.	Curtiss McLaughlin	(1) (1)	0.0	24.8	—0.5	25.3	+0.5	—0.5	0.7
14	1920, Mar. 22	Delphos, Ohio.	Peltier	1	—29.5	24.0	—0.2	22.5	—29.3	+1.5	(26.9)
15	1920, Mar. 22	Delphos, Ohio.	Peltier	1	+2.6	26.0	—0.2	22.5	+2.8	+3.5	4.3
16	1920, Mar. 22	Urbana, Ill.	Stebbins Wylie	(9) (5)	+1.1	+20.5	+1.1	+21.2	0.0	—0.7	0.7

(1) On or near meridian declination +23°. (Barnard, *Nature*, **95**, 536, 1915).

(2) Comparison with magnetic zenith, published by observer in altitude and azimuth. (Trowbridge, *Science*, **44**, 717, 1916). Transformed to hour angle and declination for this discussion.

(3) Comparison with magnetic zenith, published by observer in altitude and azimuth. (Stebbins, *R. A. S. C.*[1] **11**, 133, 1917). Transformed to hour angle and declination for this discussion.

(4) Comparison with magnetic zenith, published by observer in altitude and azimuth. (Chant, *R. A. S. C.* **11**, 400, 1917). Transformed to hour angle and declination for this discussion.

(5) Comparison with magnetic zenith published by observer in right ascension and declination. (Stebbins, *Science*, **47**, 314, 1918). Transformed to hour angle and declination for this discussion.

(6) Published in right ascension and declination. Half weight to second estimate, considered weaker by observer. (Barnard, *P. A.*[2] **26**, 377, 1918).

(7) Position measured from Saturn and stars in Great Dipper. (Burling, *Science*, **47**, 460, 1918).

(8) Corona in Comae. Group near 16 Comae adopted as position for reduction. (Duncan, *P. A.* **26**, 506, 1918).

(9) Nearly on meridian at seventy degrees altitude. (Duncan, *P. A.* **28**, 310, 1920).

(10) Vertex around Regulus. (Culp, *P. A.* **28**, 310, 1920).

(11) Three estimates with respect to Beta and Delta Geminorum. (Hunter, *R. A. S. C.* **14**, 128, 1920).

(12) Radiant of Leonids. Time not given. (Kennedy, *P. A.* **28**, 308, 1920).

(13) About fifteen degrees south of the zenith. (Curtiss, *P. A.* **28**, 307, 1920). About twenty degrees south of the zenith. (McLaughlin, *P. A.* **28**, 308, 1920).

(14) Published in right ascension and declination. (Peltier, *P. A.* **28**, 312, 1920). (First estimate.)

[1]*The Journal of the Royal Astronomical Society of Canada.* [2]*Popular Astronomy.*

(15) Published in right ascension and declination. (Peltier, *P. A.* **28**, 312, 1920). (Second estimate.)
(16) Comparison with magnetic zenith published as here given. (Stebbins, *Science*, **41**, 485, 1920).

Doubtless most of the single estimates are rough positions and the residuals, except (7) and (14), can be considered possible errors of observation. For example, in the reference cited for (4) we find the following comment by the observer: "The estimate of the position of the focus was only a rough approximation and it may be that it actually coincided with the magnetic zenith."

Observations (7) and (14), having outstanding residuals, were especially investigated. In a personal letter Mr. Burling writes that at Ottawa when he made observation (7) "the distribution of streamers was not uniform, there being few to the south." In the published description he refers to the light near the "convergent" being arranged in a hyperbola form. There was evidently no true corona.

Mr. Peltier, who made observations (14) and (15) writes that (14) was made early in the evening before the display was well developed and that "the estimate was based on the focus of several long rays from the E. N. E. and N. W." It is interesting to note that these streamers were roughly parallel to the ecliptic. Irregularities in lighting, even though introducing a large error in the estimated hour angle should have small effect on the declination; and we find that, although the estimated hour angle differs, the estimated declination is practically that of the magnetic zenith.

Where a true corona has been observed, its position practically coincides with that of the magnetic zenith. Estimates of the focus of the rays in lesser displays do not agree so well, but the difficulty of observation is much greater. With two exceptions, the observations investigated show the radiant of the streamers approximately at the magnetic zenith. As the observations disagreeing were made under unfavorable conditions, it is not certain that we find any exception to the rule that the auroral rays follow closely the magnetic lines of force.

UNIVERSITY OF ILLINOIS OBSERVATORY,
November 23, 1920.

'RELIMINARY RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE FROM COLOMBO, CEYLON, TO FREMANTLE, WESTERN AUSTRALIA, AND LYTTELTON, NEW ZEALAND, JULY TO OCTOBER, 1920.[1]

By J. P. Ault, *Commanding the Carnegie.*

)bservers: J. P. Ault, H. F. Johnston, R. R. Mills, H. R. Grummann, and R. Pemberton.)

Date	Latitude	Long. East of Gr.	Carnegie Values			Chart Values				Chart Differences[2]			
			Decl'n	Incl'n	Hor. Int.	Decl'n		Incl'n	H. In.	Decl'n		Incl'n	H. In.[3]
						Brit.	U.S.	U.S.	U.S.	Brit.	U.S.	U.S.	U.S.
1920	° ′	° ′	°	°	c.g.s.	°	°	°	c.g.s.	°	°	°	
ıly 24	6 36 N	79 50	2.8W	......	......	3.0W	2.6W	......	......	0.2 E	0.2W	......	......
25	5 01 N	80 04	2.9W	......	......	3.3W	2.8W	......	......	0.4 E	0.1W	......	......
25	4 36 N	80 26	......	9.6 S	.381	......	......	9.8 S	.377	......	......	0.2 N	+4
25	4 34 N	80 50	3.1W	......	......	3.4W	3.0W	......	......	0.3 E	0.1W	......	......
26	4 27 N	82 30	2.9W	......	......	3.3W	2.9W	......	......	0.4 E	0.0	......	......
26	4 15 N	83 47	......	10.9 S	.381	......	......	10.9 S	.380	......	......	0.0	+1
26	4 09 N	84 04	3.3W	......	......	3.2W	2.8W	......	......	0.1W	0.5W	......	......
27	3 31 N	85 52	2.7W	......	......	3.2W	2.8W	......	......	0.5 E	0.1 E	......	......
27	3 09 N	86 58	......	13.6 S	.384	......	......	12.8 S	.382	......	......	0.8 S	+2
27	3 02 N	87 22	2.8W	......	......	3.0W	2.7W	......	......	0.2 E	0.1W	......	......
28	2 25 N	89 13	2.7W	......	......	2.8W	2.5W	......	......	0.1 E	0.2W	......	......
28	2 05 N	90 13	......	16.4 S	.384	......	......	15.1 S	.382	......	......	1.3 S	+2
28	2 01 N	90 23	2.6W	......	......	2.6W	2.4W	......	......	0.0	0.2W	......	......
29	1 32 N	91 50	1.9W	......	......	2.4W	2.2W	......	......	0.5 E	0.3 E	......	......
29	1 32 N	92 28	......	17.6 S	.385	......	......	16.9 S	.382	......	......	0.7 S	+3
30	1 15 N	93 07	1.9W	......	......	2.1W	1.9W	......	......	0.2 E	0.0	......	......
30	0 59 N	93 28	......	19.0 S	.383	......	......	17.6 S	.382	......	......	1.4 S	+1
30	0 50 N	93 34	1.9W	......	......	2.0W	1.9W	......	......	0.1 E	0.0	......	......
31	0 02 N	94 04	2.0W	......	......	2.0W	1.9W	......	......	0.0	0.1W	......	......
31	0 20 S	94 03	......	21.8 S	.380	......	......	21.2 S	.379	......	......	0.6 S	+1
31	0 30 S	94 04	1.9W	......	......	2.0W	2.0W	......	......	0.1 E	0.1 E	......	......
ug. 1	1 55 S	94 07	......	25.4 S	.375	......	......	24.0 S	.374	......	......	1.4 S	+1
1	2 01 S	94 07	2.1W	......	......	2.2W	2.1W	......	......	0.1 E	0.0	......	......
2	3 06 S	94 16	2.4W	......	......	2.3W	2.2W	......	......	0.1W	0.2W	......	......
2	3 39 S	94 29	......	28.8 S	.369	......	......	27.2 S	.368	......	......	1.6 S	+1
2	3 46 S	94 36	2.4W	......	......	2.4W	2.3W	......	......	0.0	0.1W	......	......
3	4 37 S	95 03	2.4W	......	......	2.4W	2.4W	......	......	0.0	0.0	......	......
3	5 06 S	95 17	......	31.7 S	.362	......	......	30.9 S	.360	......	......	0.8 S	+2
3	5 19 S	95 21	2.5W	......	......	2.5W	2.4W	......	......	0.0	0.1W	......	......
4	6 17 S	95 34	2.6W	......	......	2.7W	2.5W	......	......	0.1 E	0.1W	......	......

[1]For previous table, see *Terr. Mag.*, v. 25, pp. 117-122.

[2]Charts used for comparison: U. S. Hydrographic Office Charts Nos. 1700, 1701, and 2406 for 1920; British Admiralty harts Nos. 3776 and 3777 for 1917. The chart differences are obtained by subtracting chart values, derived as explained in evious sentence, from the observed *Carnegie* values. In order to explain the significance of the letters *E*, *W*, *N*, *S*, as affecting ie application of the chart differences, it may be stated that *E* and *N* have been treated as being plus, *W* and *S* as minus, the iart difference being equal to the *Carnegie* value minus the chart value. The horizontal intensity is always regarded as positive, id the signs, plus and minus, have their usual significance. Secular corrections have been applied to declinations only.

[3]Expressed in units of third decimal C. G. S.

[4]Local disturbance off Cape Naturaliste, Australia.

Date	Latitude	Long. East of Gr.	Carnegie Values			Chart Values				Chart Differences[2]			
			Decl'n	Incl'n	Hor. Int.	Decl'n		Incl'n	H. In.	Decl'n		Incl'n	H. I
						Brit.	U.S.	U.S.	U.S.	Brit.	U.S.	U.S.	U.S.
1920	° ′	° ′	°	°	c.g.s.	°	°	°	c.g.s.	°	°	°	
Aug. 4	6 38 S	95 37	......	35.1 S	.355	......	......	33.7 S	.350	......	......	1.4 S	+5
4	6 50 S	95 37	2.7W	......	......	2.8W	2.6W	......	......	0.1 E	0.1W	......	...
5	7 43 S	95 36	2.9W	......	......	3.0W	2.8W	......	......	0.1 E	0.1W	......	...
5	8 12 S	95 31	......	37.5 S	.347	......	......	36.4 S	.342	......	......	1.1 S	+3
5	8 21 S	95 26	3.0W	......	......	3.2W	3.0W	......	......	0.2 E	0.0	......	...
6	9 02 S	95 05	3.4W	......	......	3.5W	3.2W	......	......	0.1 E	0.2W	......	...
6	9 27 S	94 53	......	39.7 S	.341	......	......	38.4 S	.336	......	......	1.3 S	+5
6	9 36 S	94 48	3.6W	......	......	3.8W	3.5W	......	......	0.2 E	0.1W	......	...
7	10 16 S	94 23	4.0W	......	......	4.2W	3.8W	......	......	0.2 E	0.2W	......	...
8	11 41 S	93 22	5.0W	......	......	5.1W	4.6W	......	......	0.1 E	0.4W	......	...
8	12 22 S	92 55	......	44.7 S	.322	......	......	44.0 S	.318	......	......	0.7 S	+4
9	14 11 S	91 07	7.0W	......	......	7.2W	6.3W	......	......	0.2 E	0.7W	......	...
9	14 56 S	90 24	......	48.5 S	.305	......	......	47.0 S	.304	......	......	1.5 S	+1
9	15 12 S	90 10	7.9W	......	......	8.0W	7.2W	......	......	0.1 E	0.7W	......	...
10	16 53 S	88 30	9.5W	......	......	9.4W	8.7W	......	......	0.1W	0.8W	......	...
10	17 44 S	87 45	......	51.8 S	.286	......	......	51.2 S	.284	......	......	0.6 S	+2
10	17 56 S	87 35	10.2W	......	......	10.2W	9.9W	......	......	0.0	0.3W	......	...
11	19 32 S	86 04	11.9W	......	......	11.6W	11.5W	......	......	0.3W	0.4W	......	...
11	20 24 S	85 26	......	54.7 S	.267	......	......	54.1 S	.266	......	......	0.6 S	+1
11	20 33 S	85 22	13.0W	......	......	12.7W	12.4W	......	......	0.3W	0.6W	......	...
12	21 58 S	84 02	14.1W	......	......	13.9W	14.0W	......	......	0.2W	0.1W	......	...
12	22 38 S	83 20	......	56.8 S	.251	......	......	56.3 S	.252	......	......	0.5 S	−1
12	22 48 S	83 10	14.8W	......	......	14.9W	14.6W	......	......	0.1 E	0.2W	......	...
13	24 05 S	82 03	16.4W	......	......	16.0W	15.9W	......	......	0.4W	0.5W	......	...
13	24 39 S	81 22	......	58.9 S	.239	......	......	58.2 S	.237	......	......	0.7 S	+2
13	24 48 S	81 10	17.2W	......	......	16.7W	16.5W	......	......	0.5W	0.7W	......	...
14	25 54 S	79 39	18.2W	......	......	17.8W	17.4W	......	......	0.4W	0.8W	......	...
14	26 15 S	79 08	......	60.1 S	.228	......	......	59.8 S	.231	......	......	0.3 S	−3
14	26 20 S	78 53	18.8W	......	......	18.2W	17.9W	......	......	0.6W	0.9W	......	...
15	25 39 S	80 15	18.6W	......	......	17.5W	17.1W	......	......	1.1W	1.5W	......	...
16	26 55 S	78 27	19.6W	......	......	18.7W	18.4W	......	......	0.9W	1.2W	......	...
16	27 13 S	77 56	......	60.3 S	.224	......	......	60.3 S	.220	......	......	0.0	+4
16	27 18 S	77 46	19.8W	......	......	19.1W	18.7W	......	......	0.7W	1.1W	......	...
17	27 55 S	76 56	20.6W	......	......	19.5W	19.4W	......	......	1.1W	1.2W	......	...
17	28 13 S	76 28	......	61.0 S	.217	......	......	60.9 S	.214	......	......	0.1 S	+3
17	28 16 S	76 24	20.9W	......	......	19.8W	19.8W	......	......	1.1W	1.1W	......	...
18	29 05 S	75 18	20.8W	......	......	20.3W	20.2W	......	......	0.5W	0.6W	......	...
18	29 26 S	74 51	......	61.4 S	.213	......	......	61.6 S	.208	......	......	0.2 N	+5
18	29 39 S	74 37	22.4W	......	......	20.6W	20.5W	......	......	1.8W	1.9W	......	...
19	30 41 S	74 05	......	62.2 S	.207	......	......	62.2 S	.202	......	......	0.0	+5
19	30 53 S	74 04	23.2W	......	......	21.8W	21.3W	......	......	1.4W	1.9W	......	...
20	32 18 S	75 40	24.8W	......	......	23.5W	23.4W	......	......	1.3W	1.4W	......	...
20	32 43 S	76 06	......	63.7 S	.203	......	......	63.7 S	.198	......	......	0.0	+5
20	32 55 S	76 22	25.1W	......	......	24.3W	24.1W	......	......	0.8W	1.0W	......	...
21	33 38 S	78 41	25.5W	......	......	25.2W	25.1W	......	......	0.3W	0.4W	......	...
21	33 50 S	79 47	......	65.0 S	.203	......	......	64.8 S	.198	......	......	0.2 S	+5
21	33 54 S	80 05	26.6W	......	......	25.6W	25.2W	......	......	1.0W	1.4W	......	...
22	34 27 S	82 40	26.2W	......	......	26.0W	25.8W	......	......	0.2W	0.4W	......	...
22	34 44 S	83 50	......	66.2 S	.199	......	......	65.9 S	.198	......	......	0.3 S	+1

ate	Latitude	Long. East of Gr.	Carnegie Values Decl'n	Carnegie Values Incl'n	Carnegie Values Hor. Int.	Chart Values Decl'n Brit.	Chart Values Decl'n U.S.	Chart Values Incl'n U.S.	Chart Values H. In. U.S.	Chart Differences[2] Decl'n Brit.	Chart Differences[2] Decl'n U.S.	Chart Differences[2] Incl'n U.S.	Chart Differences[2] H. In.[3] U.S.
'20	° ′	° ′	°	°	c.g.s.	°	°	°	c.g.s.	°	°	°	
22	34 45 S	84 06	26.1W	......	......	26.3W	25.8W	......	......	0.2 E	0.3W	......	......
23	35 01 S	86 23	25.5W	......	......	25.9W	25.1W	......	......	0.4 E	0.4W	......	......
23	35 07 S	87 37	......	67.2 S	.201	......	......	66.6 S	.200	......	......	0.6 S	+1
23	35 08 S	87 50	25.7W	......	......	25.6W	24.9W	......	......	0.1W	0.8W	......	......
24	35 15 S	90 38	24.7W	......	......	24.4W	24.0W	......	......	0.3W	0.7W	......	......
24	35 16 S	90 58	23.9W	......	......	24.2W	23.9W	......	......	0.3 E	0.0	......	......
24	35 23 S	92 12	......	68.0 S	.202	......	......	67.7 S	.202	......	......	0.3 S	0
24	35 27 S	92 54	23.6W	......	......	23.4W	23.1W	......	......	0.2W	0.5W	......	......
25	35 37 S	94 48	21.9W	......	......	22.4W	22.2W	......	......	0.5 E	0.3 E	......	......
25	35 48 S	95 49	......	68.7 S	.202	......	......	68.2 S	.204	......	......	0.5 S	−2
25	35 52 S	96 03	21.8W	......	......	21.9W	21.8W	......	......	0.1 E	0.0	......	......
26	35 39 S	98 28	19.9W	......	......	20.0W	19.3W	......	......	0.1 E	0.6W	......	......
26	35 26 S	99 45	......	68.8 S	.205	......	......	68.4 S	.208	......	......	0.4 S	−3
27	35 08 S	102 11	16.2W	......	......	16.4W	16.1W	......	......	0.2 E	0.1W	......	......
27	35 00 S	103 20	......	58.6 S	.208	......	......	68.2 S	.213	......	......	0.4 S	−5
27	34 56 S	103 33	15.6W	......	......	15.4W	15.0W	......	......	0.2W	0.6W	......	......
28	34 42 S	105 58	13.1W	......	......	13.3W	12.9W	......	......	0.2 E	0.2W	......	......
28	34 33 S	107 24	......	68.9 S	.211	......	......	68.2 S	.217	......	......	0.7 S	−6
28	34 29 S	107 41	12.3W	......	......	11.6W	11.5W	......	......	0.7W	0.8W	......	......
29	33 41 S	110 27	......	67.7 S	.224	......	......	67.4 S	.224	......	......	0.3 S	0
29	33 36 S	110 39	9.2W	......	......	8.8W	8.7W	......	......	0.4W	0.5W	......	......
30	32 32 S	112 38	6.6W	......	......	7.0W	6.8W	......	......	0.4 E	0.2 E	......	......
30	32 18 S	113 25	......	66.1 S	.236	......	......	66.2 S	.234	......	......	0.1 N	+2
30	32 16 S	113 41	6.1W	......	......	6.3W	6.2W	......	......	0.2 E	0.1 E	......	......

Notes on Trip from Colombo to Fremantle.

We left Colombo the morning of July 24 and were towed ten miles off shore against the prevailing southwest monsoon. At noon we let go the tugboat, started our own engine and proceeded southeasterly under fore-and-aft sails, close hauled to clear the southwest point of Ceylon. At midnight the wind hauling more to the westward, the engine was stopped and we proceeded under full sail.

Considerations of prevailing winds for July and August made it seem desirable to cross the Equator in longitude 95° east, so it was decided to make easting north of "the line" instead of south. Accordingly on July 25 our course was changed to an easterly direction and a good run was made in the southwest monsoon until July 29, when this wind died out. The extent of the calm belt encountered next proved the wisdom of taking the northerly course. During the nine days from July 29 to August 7, the vessel made over 800 miles under her engine alone through a continuous calm. Instead of picking up the southeast trade wind near latitude 3° south as expected, no wind was found until we had reached the latitude of 10° south. On the morning of August 7 the sea became rough and the engine was stopped.

Date	Latitude	Long. East of Gr.	Carnegie Values			Chart Values				Chart Differences[2]			
			Decl'n	Incl'n	Hor. Int.	Decl'n		Incl'n	H. In.	Decl'n		Incl'n	H.
						Brit.	U.S.	U.S.	U.S.	Brit.	U.S.	U.S.	U
1920	° ′	° ′	°	°	c.g.s.	°	°	°	c.g.s.	°	°	°	
Oct. 1	32 12 S	115 20	4.9W	......	......	5.3W	5.5W	......	......	0.4 E	0.6 E	......	..
2	33 09 S	114 43	4.8W[4]	......	......	6.3W	6.4W	......	......	1.5 E	1.6 E	......	..
3	35 15 S	115 57	6.3W	......	......	6.7W	6.7W	......	......	0.4 E	0.4 E	......	..
3	35 24 S	116 14	......	68.6 S	.215	......	......	68.2 S	.220	......	......	0.4 S	–
3	35 27 S	116 19	6.9W	......	......	6.6W	6.7W	......	......	0.3W	0.2W	......	..
4	36 42 S	116 56	7.3W	......	......	7.0W	7.0W	......	......	0.3W	0.3W	......	..
4	37 50 S	117 42	......	70.1 S	.201	......	......	70.2 S	.206	......	......	0.1 N	–
4	38 05 S	117 52	7.6W	......	......	7.2W	7.4W	......	......	0.4W	0.2W	......	..
5	39 50 S	119 07	7.9W	......	......	7.4W	7.4W	......	......	0.5W	0.5W	......	..
5	41 01 S	119 58	......	72.5 S	.184	......	......	72.5 S	.186	......	......	0.0	–
5	41 19 S	120 10	8.1W	......	......	7.7W	7.6W	......	......	0.4W	0.5W	......	..
6	42 52 S	121 08	8.7W	......	......	8.3W	8.0W	......	......	0.4W	0.7W	......	..
6	43 21 S	122 10	......	74.3 S	.167	......	......	74.3 S	.168	......	......	0.0	–
6	43 24 S	122 21	8.0W	......	......	7.6W	7.5W	......	......	0.4W	0.5W	......	..
7	44 18 S	125 12	6.2W	......	......	5.9W	6.0W	......	......	0.3W	0.2W	......	..
7	44 30 S	126 25	......	74.6 S	.167	......	......	74.7 S	.164	......	......	0.1 N	+
7	44 30 S	126 26	4.2W	......	......	5.1W	5.0W	......	......	0.9 E	0.8 E	......	..
8	44 56 S	126 47	......	75.0 S	.161	......	......	75.0 S	.163	......	......	0.0	–
8	44 58 S	127 51	4.0W	......	......	4.2W	4.2W	......	......	0.2 E	0.2 E	......	..
8	45 05 S	128 00	4.3W	......	......	4.2W	4.1W	......	......	0.1W	0.2W	......	..
9	46 08 S	129 32	3.2W	......	......	3.4W	3.5W	......	......	0.2 E	0.3 E	......	..
9	46 51 S	130 41	......	76.7 S	.148	......	......	76.2 S	.150	......	......	0.5 S	–
10	48 31 S	134 17	0.0	......	......	0.3W	0.4W	......	......	0.3 E	0.4 E	......	..
10	48 55 S	135 18	......	77.1 S	.144	......	......	77.5 S	.140	......	......	0.4 N	+
11	49 46 S	137 55	2.5 E	......	......	1.4 E	1.6 E	......	......	1.1 E	0.9 E	......	..
11	49 49 S	138 02	2.2 E	......	......	1.5 E	1.7 E	......	......	0.7 E	0.5 E	......	..
11	50 02 S	139 10	......	77.9 S	.137	......	......	78.0 S	.136	......	......	0.1 N	+
11	50 03 S	139 22	3.4 E	......	......	2.7 E	3.0 E	......	......	0.7 E	0.4 E	......	..
12	50 20 S	142 25	6.8 E	......	......	5.5 E	5.8 E	......	......	1.3 E	1.0 E	......	..
12	50 21 S	144 08	......	77.6 S	.138	......	......	77.7 S	.138	......	......	0.1 N	
12	50 20 S	144 22	8.2 E	......	......	7.5 E	7.4 E	......	......	0.7 E	0.8 E	......	..
13	50 30 S	147 05	10.4 E	......	......	9.6 E	9.5 E	......	......	0.8 E	0.9 E	......	..
13	50 35 S	148 31	......	77.7 S	.140	......	......	76.9 S	.143	......	......	0.8 S	–
13	50 34 S	148 52	12.0 E	......	......	10.9 E	10.8 E	......	......	1.1 E	1.2 E	......	..
14	49 56 S	151 09	13.1 E	......	......	12.3 E	12.3 E	......	......	0.8 E	0.8 E	......	..
14	49 38 S	152 36	......	75.9 S	.155	......	......	75.6 S	.156	......	......	0.3 S	–
14	49 31 S	152 53	13.7 E	......	......	13.3 E	13.0 E	......	......	0.4 E	0.7 E	......	..
15	47 58 S	156 16	......	74.1 S	.173	......	......	74.1 S	.173	......	......	0.0	
15	47 56 S	156 36	14.6 E	......	......	14.6 E	14.7 E	......	......	0.0	0.1W	......	..
16	47 34 S	160 36	......	73.1 S	.183	......	......	73.2 S	.183	......	......	0.1 N	
16	47 38 S	160 56	16.2 E	......	......	16.1 E	16.2 E	......	......	0.1 E	0.0	......	..
17	47 59 S	163 46	16.9 E	......	......	17.0 E	17.1 E	......	......	0.1W	0.2W	......	..
17	48 00 S	165 24	......	72.9 S	.185	......	......	72.6 S	.186	......	......	0.3 S	–
17	47 59 S	165 53	18.4 E	......	......	17.5 E	17.6 E	......	......	0.9 E	0.8 E	......	..
18	47 44 S	168 28	18.4 E	......	......	17.9 E	17.9 E	......	......	0.5 E	0.5 E	......	..
18	47 34 S	168 43	18.3 E	......	......	17.9 E	18.0 E	......	......	0.4 E	0.3 E	......	..
18	46 42 S	169 54	......	70.8 S	.204	......	......	71.2 S	.200	......	......	0.4 N	+
18	46 18 S	170 17	18.2 E	......	......	17.7 E	17.8 E	......	......	0.5 E	0.4 E	......	..
19	45 41 S	171 12	18.0 E	......	......	17.6 E	17.6 E	......	......	0.4 E	0.4 E	......	..
19	45 22 S	171 38	......	69.7 S	.210	......	......	69.8 S	.210	......	......	0.1 N	
19	45 18 S	171 46	18.0 E	......	......	17.5 E	17.6 E	......	......	0.5 E	0.4 E	......	..
20	44 42 S	172 30	17.6 E	......	......	17.4 E	17.3 E	......	......	0.2 E	0.3 E	......	..
20	44 25 S	172 51	......	68.7 S	.218	......	......	68.7 S	.218	......	......	0.0	
20	44 16 S	173 03	17.6 E	......	......	17.3 E	17.3 E	......	......	0.3 E	0.3 E	......	..

From the afternoon of August 7 until August 19, we had a heavy southeast trade wind, which unexpectedly continued until the latitude of 31° south was reached. This run put us about 600 miles off our projected route, but fortunately gave us two crossings of the 1911 *Carnegie* track in a region where the annual change in the magnetic declination is quite large.

For five days after the southeast trade the wind held from a northeasterly direction. On August 24 it shifted to north and northwest in a gale with rapidly falling barometer and held at west after the barometer ceased falling and began to rise. This gale moderated to a strong breeze on August 25 and continued to blow from the westward until August 28, when the wind shifted to the north and began another gale, which continued until August 30. We reached Fremantle at 10:30 P. M. August 31, going the last eight hours under our engine with calms and against head winds.

The total distance traversed was 5,650 miles, which gives a daily average of 147 miles for the 38.5 days at sea.

Notes on the Trip from Fremantle to Lyttelton.

After a delay of one day spent in preparing records ready for the mail and in securing two seamen needed to fill the ship's complement, we left Fremantle on October 1 at 10:20 A. M., and were towed well out against a light head wind. During the night the northwest and west-northwest wind together with a southerly current set the vessel well in toward Cape Naturaliste, so that by eight o'clock on October 2 we were only 10 miles off the Cape. A gale from the west was blowing at the time with heavy squalls, making it uncertain that the vessel could clear Cape Leeuwin. It was decided to run the engine and proceed, trusting that the wind would not shift ahead until we got clear of the Cape. The engine held the vessel up to her course very well, probably overcoming a point of lee-way.

We were thus skirting the coast at a distance of about 10 miles from 8^h until 21^h, the wind shifting ahead just slowly enough to allow us to keep a clear course with careful steering, as the direction of the coast line changed from S by W to SSE. We cleared the dangerous point of Cape Leeuwin at a distance of three miles. The gale died down to a calm during the night, as we proceeded on our way south into the cold and stormy region of the high latitudes.

On October 5 the next gale began from the northeast and continued with fog, mist and rain until October 7, shifting through west to southwest.

Another short gale blew from the northwest on the night of October 10. A display of *Aurora Australis* was visible during the entire night of *October 10, 1920, and again on October 11*, in the form of a series of arches of white light stretched across the southern sky, with white vertical streamers extending up to the zenith.

At 8^h 15^m October 12, the vessel was within one mile of the *charted position of the Royal Company Islands*. Stieler's Atlas gives the position as 50° 24′ S, 142° 45′ E; H. R. Mill gives 50° 15′ S and 142° 45′ E, and Bartholomew gives 50° 18′ S and 143° 00′ E; the mean of these, 50° 20′ S and 142° 50′ E, was the position assumed. Nothing was in sight for a radius of 40 miles with very good visibility. The *Carnegie* sailed eastward all day at about 50° 20′ south latitude and there were no signs of land. These islands have been searched for unsuccessfully by several navigators and they might well be eliminated from the charts. Our own experience in these latitudes in 1915-1916 showed the ease with which icebergs could be taken for land, when seen at distances even less than 5 miles. For several days before reaching the position given for the Royal Company Islands, birds were particularly numerous, albatross, molly-mawks, petrels, cape-pigeons, etc., and penguins were heard near the vessel at night. Floating kelp was passed in considerable quantities. But these indications cannot be taken always as signs of the proximity of land, as has often been done by earlier navigators in confirmation of their reports of new islands found.

Our heaviest weather began on October 12, a westerly wind developing into a gale, shifting to northwest, back to southwest, again to northwest, and back again to southwest on October 15, moderating at south on October 16, and maintaining a force of 7 to 9 during the entire five days. The heavy wind and sea from the northwest prevented our making the northing necessary for a passage through Cook Strait useful, so it was decided to proceed to Lyttelton by way of the Snares south of South Island, a much easier, safer, and direct route.

The Snares were picked up on October 17, as calculated, and anchor was dropped in Lyttelton Harbor at 3^h 15^m, A. M., of October 21. Owing to calms and head winds the engine was operated for two days before arrival at Lyttelton. The last 50 miles were made running before a heavy southeast wind that came out of a practically clear sky, within one minute of the dying out of the northeast wind that had been blowing for several hours.

The usual meteorological conditions for these latitudes were experienced, but a fairly complete program of observations was carried out in spite of fogs, storms, and heavy seas. Declination observations were made daily and usually twice a day. The total number of miles traversed from Fremantle to Lyttelton was 3,157. Hence, the average daily run for the 19.7 days at sea was 160.3 nautical miles.

MAGNETIC STORM OF AUGUST 11, 1919, AT VASSOURAS MAGNETIC OBSERVATORY.[1]

By A. Lemos.

(Latitude: 22° 23′ 57″ S; Longitude: 43° 39′ 00″ W of Gr.)

Declination (*D*).—The sudden commencement was at 7 h 00 m, G. M. T., there being a fall of 5′, followed by a series of rapid oscillations, superposed on others of greater period and irregularity. The greatest value, 11° 19′.0 W, occurred at 8 h, G. M. T., and the minimum, 10° 59′.0 W, at 15 h 54 m. The extreme range of the variation was thus 20′. At 21 h, the disturbance diminished in intensity; it disappeared completely at 19 h 07 m on August 12. From this time until 11 h 00 m, on August 13, the value of the declination remained constant at 11° 12′.0 W.

Horizontal Intensity (*H*).—The sudden commencement took place also at 7 h 00 m, G. M. T., the trace going beyond the limits of the magnetogram; thus the intensity was greater than 24654γ. After this time, the intensity began to diminish until 11 h 02 m, when the minimum value, 24218γ, was reached; this minimum was preceded by a very disturbed series of vibrations of small amplitude and period, superposed on oscillations of greater amplitude and period. In one of these oscillations, the intensity showed a variation of 168γ in 21 minutes. From the time of the minimum to 4 h, on August 12, the horizontal-intensity curve presented an aspect more or less identical to the one described, the intensity increasing until it reached the value of 24626γ at 17 h 00 m, on August 11. From 4 h on August 12, the magnetic disturbance diminished in intensity until it disappeared completely at 19 h 09 m on August 12, the value being at that time 24466γ, which continued to increase almost imperceptibly showing a total increase of 17γ in 16 hours; the curve thus maintained itself almost parallel to the axis of abscissas. The mean diurnal ordinates of August 10 and 13, which preceded and followed the perturbation, were, respectively, 24542γ and 24487γ, and for the two days August 11 and 12, 24423γ and 24478γ, respectively.

In short, the curve shows the characteristic form indicated by Dr. Chree, namely, increase of *H* with reference to the pre-storm value in the first hour; decrease directly afterwards, in spite of the oscillations described; then, a return to the pre-storm value.

Vertical Intensity (*Z*).—The sudden commencement was at 7 h 03 m, with a decrease in the value of *Z* of 20γ. The disturbance is on a smaller scale and inverse to the principal characteristics of the horizontal-intensity variation. The greater phase of the storm also corresponds to that of the horizontal intensity, likewise disappearing at 19 h 09 m on August 12. The minimum occurred at 7 h 15 m and the maximum at 10 h 03 m, the values being 6656γ and 6764γ, respectively. From 19 h 09 m until 9 h 00 m, G. M. T., on August 13, the value of the vertical intensity remained almost stationary. The mean diurnal ordinates were 6668γ, 6679γ, 6679γ, and 6674γ, on August 10, 11, 12, and 13, respectively.

[1]Communicated by Dr. H. Morize, Director of the National Meteorological and Astronomical Observatory of Brazil.

RECORDS OF EARTHQUAKES AT WATHEROO MAGNETIC OBSERVATORY.

By Edward Kidson.

The following particulars are given of earthquakes recorded on the magnetograms of the Watheroo Observatory, Western Australia. All times refer to 120th east meridian standard time. The *geographic coördinates* are: latitude 30° 18′ S; longitude, 115° 53′ E. See previous issues for records of earthquakes already reported upon.

November 18, 1919.—Times of commencement, $12^h\ 06^m$ and $12^h\ 05^m$, in declination and horizontal intensity, respectively; commencement of large waves, $12^h\ 10^m$, in declination; end of large waves, $12^h\ 16^m$, in declination. There was no perceptible record in vertical intensity. The maximum amplitude reached in declination was 0.6 mm, and the declination trace was again of normal width by $12^h\ 18^m$.

June 9, 1920.—The record began at $19^h\ 38^m$ and ended at $19^h\ 57^m$ on the horizontal-intensity magnetogram and reached a maximum amplitude of 1.2 mm. The effect was scarcely perceptible on the declination and vertical-intensity magnetograms.

July 15, 1920.—There was a record both in declination and in horizontal intensity, but not in vertical intensity, the time of beginning being $18^h\ 59^m$, the times of ending being $19^h\ 08^m$ for declination, and $19^h\ 07^m$ for horizontal intensity. The record is especially marked in the declination trace which shows two lozenge-shaped swellings each with a maximum amplitude of about 2.0 mm. In the horizontal-intensity trace there are a few oscillations with an amplitude of about 1.5 mm. at $19^h\ 00^m$ and again at $19^h\ 03^m$, while for the rest of the time the oscillations are of very small amplitude. The declination record is distinctly reminiscent of that of a Milne seismograph.

August 13, 1920.—The record is only in the horizontal-intensity trace, and shows as a slight thickening of the trace between $11^h\ 18^m$ and $11^h\ 23^m$.

September 21, 1920.—The particulars are given in the following table:

Phase	*D*	*H*	*Z*
	h m	h m	h m
Beginning	22 48	22 51	23 06
Time of amplitude	23 10	23 04, 23 10	23 10
Ending	23 12	23 20	23 15
Maximum amplitude	0.9 mm.	1.4 mm.	1.2 mm.

The two sets of relatively large waves, centered about $22^h\ 49^m$ and $23^h\ 10^m$, respectively, were recorded on the declination-trace.

MAGNETIC OBSERVATIONS AT KEW, MAY 28-30, 1919.

By Charles Chree, *Superintendent.*

[Table 1 has been derived from Dr. Chree's article in *Terr. Mag.* vol. 24, p. 170. Dr. Chree assigns the "magnetic character" figure, as judged from the D and H curves, zero to each of the three days, May 28, 29, 30, 1919. Tables 2 and 3 have been derived from data subsequently received. The *geographic coördinates* of the Kew Magnetic Observatory are: Latitude, 51° 28.1 W.; longitude, 0° 18′.8 or 1 m.3 W.—*Ed.*]

Table 1.—*Declination hourly values and diurnal variation.*

[D = W 14° 30′ + tabular quantity; N = mean of May 28 and 30; *29* = May 29; dD = diurnal variation.]

Hour	D		dD		Hour	D		dD		Hour	D		dD	
	N	29	*N*	29		*N*	29	*N*	29		*N*	29	*N*	29
h	′	′	′	′	h	′	′	′	′	h	′	′	′	′
1	11.4	11.1	−0.5	+0.8	09	06.7	06.7	+4.2	+5.2	17	12.2	13.1	−1.3	−1.2
2	11.0	11.6	−0.1	+0.3	10	09.4	09.5	+1.5	+2.4	18	11.1	11.6	−0.2	+0.3
3	10.4	10.9	+0.5	+1.0	11	11.1	12.9	−0.2	−1.0	19	11.0	12.2	−0.1	−0.3
4	08.6	11.4	+2.3	+0.5	12	13.3	16.6	−2.4	−4.7	20	11.9	12.0	−1.0	−0.1
5	06.7	10.4	+4.2	+1.5	13	16.1	18.9	−5.2	−7.0	21	12.1	11.8	−1.2	+0.1
6	05.4	06.6	+5.5	+5.3	14	16.6	19.7	−5.7	−7.8	22	12.4	11.7	−1.5	+0.2
7	04.8	05.0	**+6.1**	+6.9	15	15.4	18.4	−4.5	−6.5	23	12.3	11.9	−1.4	0.0
8	05.2	04.9	+5.7	**+7.0**	16	14.0	15.6	−3.1	−3.7	24	11.4	11.8	−0.5	+0.1

Mean for N (May 28 and 30): 14° 40′.9 W. Mean for May 29: 14° 41′.9 W.

Table 2.—*Hourly values of horizontal intensity and diurnal variation.*

[H = 18400γ + tabular quantity; N = mean of May 28 and 30; *29* = May 29; dH = diurnal variation.]

Hr.	H		dH		Hour	H		dH		Hour	H		dH	
	N	29	*N*	29		*N*	29	*N*	29		*N*	29	*N*	29
h	γ	γ	γ	γ	h	γ	γ	γ	γ	h	γ	γ	γ	γ
1	21	20	− 2	−5	9	06	13	−17	−12	17	32	41	+ 9	+16
2	20	18	− 3	−7	10	07	08	−16	−17	18	44	34	+21	+ 9
3	19	20	− 4	−5	11	07	01	−16	−24	19	46	27	+23	+ 2
4	22	24	− 1	−1	12	09	05	−14	−20	20	39	30	+16	+ 5
5	25	30	+ 2	+5	13	12	11	−11	−14	21	37	31	+14	+ 6
6	23	27	0	+2	14	11	24	−12	− 1	22	36	35	+13	+10
7	18	27	− 5	+2	15	23	38	0	+13	23	34	31	+11	+ 6
8	12	22	−11	−3	16	21	42	− 2	+17	24	30	30	+ 7	+ 5

Mean N (May 28 and 30): 18423.3γ. Mean for May 29: 18424.5γ.

Table 3.—*Extreme values and ranges.*

Date 1919	Declination			Horizontal Intensity		
	Max. W.	Min. W.	Range	Maximum	Minimum	Range
	° ′	° ′	′	γ	γ	γ
May 28	14 46.9	14 35.4	11.5	18437	18392	45
29	14 50.4	14 35.0	15.4	18439	18392	47
30	14 48.4	14 33.7	14.7	18455	18395	60

The following extracts are taken from Dr. Chree's letter of November 6, 1920: "We have not given mean hourly values of vertical force for many years. On quiet days the uncertainties are too great when one goes to 1γ. The V absolute ranges of course are still more uncertain (unless there happens to come a storm with extreme values near midnight).

"Even as to D and H absolute ranges a caution is needed. We ceased getting these out and printing them some years ago, and the values given above cannot really claim accuracy to $0'.1$ in D or to 1γ in H. They really represent mean values during 10 minutes about the times of maximum and minimum. The days being comparatively quiet, there was little uncertainty as to the times of maximum and minimum. The traces at the busy hours of the day show incessant small oscillations and to take the extremity of one of these as a maximum or minimum would almost certainly be wrong. While the V-curves have too large artificial disturbances to justify hourly values on a quiet day, they indicate that in that element conditions were quiet for the three days."

MAGNETIC OBSERVATIONS AT AGINCOURT AND MEANOOK, MAY 29, 1919.

By Sir F. Stupart, *Director.*

[The data supplied for the Agincourt Magnetic Observatory, near Toronto, Canada, consisted of eye-reading values of magnetic declination (D), horizontal intensity (H), and vertical intensity (Z), for every minute, $9^h\ 58^m$ to $16^h\ 32^m$, Greenwich civil mean time, May 29, 1919. For the Meanook Magnetic Observatory similar data could be supplied only for D. Tables 1 and 2 contain the derived five-minute means. Furthermore, the mean diurnal variation for May 28 and 30, 1919, was transmitted (Table 3). Later were received also the hourly magnetograph values for May 28-30, 1919, from which Table 4 was derived. The *geographic coördinates* are: Agincourt (lat. 43° 47′ N.; long., 79° 16′ or $5^h\ 17^m$ W); Meanook (lat., 54° 36′.9 N.; long., 113° 20′.5 or $7^h\ 33.4^m$ W). —*Ed.*]

TABLE 1.—*Five-minute means of D, May 29, 1919.* (*Eye readings.*)

	Agincourt: D = W 6° 30′ +							Meanook: D = E 27° 30′ +						
G.M.T.	10h	11h	12h	13h	14h	15h	16h	10h	11h	12h	13h	14h	15h	16h
m	′	′	′	′	′	′	′	′	′	′	′	′	′	′
00	05.9	03.9	02.5	02.6	04.4	07.8	12.2	08.5	11.0	13.2	16.6	17.8	17.0	17.1
05	05.5	03.8	02.5	02.6	04.2	08.2	12.8	08.8	11.4	13.4	17.4	18.0	17.4	17.4
10	05.2	03.5	02.4	03.1	04.7	08.6	13.4	09.1	11.9	13.9	17.9	17.6	17.7	16.8
15	05.1	03.2	02.2	04.0	05.3	08.8	14.1	09.2	12.2	14.6	17.1	17.6	17.7	16.3
20	05.1	03.1	02.4	04.2	05.6	09.1	14.9	09.5	12.2	13.7	17.0	17.9	17.8	16.1
25	05.0	02.8	02.5	03.1	05.4	09.4	15.3	09.6	12.3	13.7	17.4	18.0	18.0	15.5
30	04.8	02.8	02.4	03.2	05.9	09.9	15.9	09.9	12.6	14.2	17.8	17.8	18.2	14.9
35	04.7	02.8	02.3	03.7	06.1	10.2	....	10.2	12.7	14.6	17.7	17.9	17.9	....
40	04.4	02.7	02.1	03.8	06.4	10.8	....	10.3	12.7	15.2	17.8	17.4	17.9	....
45	04.2	02.6	02.6	03.9	06.4	11.0	....	10.2	13.2	15.8	18.2	18.2	18.0	....
50	04.4	02.7	02.9	04.4	06.4	11.2	....	10.4	13.2	16.0	17.9	17.7	18.2	....
55	04.1	02.5	02.9	04.5	07.2	11.5	....	10.6	13.2	16.3	17.9	17.0	17.4	....

TABLE 2.—*Five-minute means of H and Z, Agincourt, May 29, 1919.* (*Eye readings.*)
[H = 15850γ + tab. quantity; Z = 58200γ + tab. quantity.]

G.M.T.	10h		11h		12h		13h		14h		15h		16h	
	H	*Z*	*H*	*Z*	*H*	*Z*	*H*	*Z*	*H*	*Z*	*H*	*Z*	*H*	*Z*
m	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
00	53	88	53	89	51	88	42	88	37	88	29	84	29	82
05	53	88	53	90	49	88	41	88	36	87	28	85	29	82
10	53	90	53	89	49	88	44	89	34	87	27	85	28	83
15	54	90	53	89	49	88	45	90	36	88	28	85	30	83
20	53	90	53	89	48	88	40	89	36	87	29	85	32	84
25	53	90	53	90	46	87	38	88	35	86	29	85	34	84
30	53	90	54	90	46	87	40	88	34	86	30	85	35	84
35	53	90	54	90	44	87	39	89	33	86	31	84	..	..
40	53	89	53	89	44	88	38	89	33	86	30	84	..	..
45	53	89	53	90	44	88	37	88	32	86	28	84	..	..
50	53	89	52	89	43	88	36	88	31	85	28	83	..	..
55	53	90	52	88	42	88	37	88	29	84	28	82	..	..

TABLE 3.—*Mean diurnal variation, May 28 and 30, 1919, for Agincourt and Meanook.*

[+ signifies greater easterly *D*, or greater *H* or *Z*, than the mean.]

G.M.T.	Agincourt			Mea.	G.M.T.	Agincourt			Mea.
	D	H	Z	D		D	H	Z	D
h	′	γ	γ	′	h	′	γ	γ	′
1	−0.8	−3.5	+4.4	−2.3	13	+6.8	−15.7	−3.6	+5.9
2	−0.7	−3.8	+3.6	−1.2	14	+3.7	−23.3	−3.9	+9.5
3	−1.0	−5.0	+4.1	−1.2	15	−0.3	−32.4	−1.3	+8.9
4	−0.4	−3.8	+2.1	−0.5	16	−5.5	−22.4	−5.9	+8.0
5	−0.7	−4.0	+3.0	−1.4	17	−7.7	−3.2	−5.0	+4.6
6	+0.1	−1.4	+1.0	−1.2	18	−6.9	+15.8	−7.6	+1.4
7	0.0	+0.8	+1.0	+0.5	19	−6.2	+20.6	−6.8	−3.7
8	+0.6	−1.4	−0.2	−0.5	20	−4.1	+25.1	−8.2	−6.7
9	+1.9	−5.4	+1.6	−2.2	21	−0.7	+20.8	+3.6	−5.1
10	+3.4	+1.7	−2.5	−1.0	22	+0.4	+13.6	+4.7	−7.6
11	+6.7	+1.2	−1.0	+2.5	23	+1.8	+13.2	+8.2	−6.0
12	+7.6	−3.5	−3.3	+3.7	24	+2.4	+9.6	+6.7	−4.3

TABLE 4.—*Hourly magnetograph values of D, H, and Z, May 28-30, 1919.*

[*N* = mean of May 28 and 30; *29* = May 29. For *Agincourt:* *D* = W 6° 30′ + tab. quant.; *H* = 15850γ + t. q.; *Z* = 58200γ + t. q. For *Meanook:* *D* = E 27° 30′ + t. q.]

G.M.T.	Agincourt						Mea.		G.M.T.	Agincourt						Mea.	
	D		*H*		*Z*		*D*			*D*		*H*		*Z*		*D*	
	N	*29*	*N*	*29*	*N*	*29*	*N*	*29*		*N*	*29*	*N*	*29*	*N*	*29*	*N*	*29*
h	′	′	γ	γ	γ	γ	′	′	h	′	′	γ	γ	γ	γ	′	′
1	11.4	12.1	55	49	71	71	07.9	07.9	13	03.9	03.2	47	40	62	68	16.2	16.6
2	11.3	11.7	54	55	70	68	09.1	09.0	14	07.0	04.7	35	35	62	67	19.8	17.8
3	11.6	11.9	54	59	71	70	09.1	09.0	15	10.9	08.2	26	26	64	65	19.2	17.0
4	11.0	10.2	54	48	68	70	09.8	09.4	16	16.2	12.7	36	27	60	61	18.2	17.0
5	11.4	09.8	54	48	70	51	08.9	16.3	17	18.4	17.4	61	45	62	64	14.8	14.3
6	10.6	11.8	57	48	68	62	09.1	05.4	18	17.6	18.9	74	60	59	64	11.6	11.4
7	10.6	09.9	59	54	67	64	10.8	08.5	19	16.9	19.0	79	69	60	65	06.6	05.3
8	10.0	09.2	57	49	66	66	09.8	06.7	20	14.8	16.3	83	79	64	67	03.5	04.6
9	08.7	08.3	53	51	68	69	08.0	09.3	21	11.4	14.4	79	72	69	68	05.1	04.4
10	07.3	06.2	60	50	64	69	09.3	08.5	22	10.3	13.0	72	68	71	66	02.7	04.2
11	03.9	04.3	59	49	66	70	12.8	11.0	23	08.9	11.4	72	64	74	68	04.3	05.1
12	03.1	02.9	55	49	63	68	13.9	13.1	24	08.3	11.0	68	60	73	66	06.0	06.2

LATEST ANNUAL VALUES OF THE MAGNETIC ELEMENTS AT OBSERVATORIES.[1]

COMPILED BY J. A. FLEMING.

Observatory	Latitude	Longitude	Year	Declination (D)	Inclination (I)	Intensity Hor. (H)	Intensity Ver. (Z)
	° ′	° ′		° ′	° ′	c. g. s.	c. g. s.
Sitka........	57 03 N	135 20W	1918	30 24.9 E	74 23.8 N	.15580	.55790
Katharinenburg......	56 50 N	60 38 E	1908	10 42.8 E	70 54.8 N	.17581	.50809
			1909	10 47.8 E	70 57.6 N	.17529	.50794
			1910	10 51.7 E	71 00.7 N	.17476	.50786
			1911	10 55.2 E	71 04.4 N	.17415	.50785
			1912	10 57.7 E	71 08.0 N	.17356	.50790
Rude Skov...	55 51 N	12 27 E	1917	8 26.0W	68 54.7 N	.17198	.44599
Kasan (old site)......	55 47 N	49 08 E	1913	8 10.9 E	69 18.2 N	.17959	.47535
Kasan (new site)......	55 50 N	48 51 E	1914[2]	8 21.3 E	69 22.1 N	.17891	.47517
Eskdalemuir..	55 19 N	3 12W	1915	17 35.9W	69 36.9 N	.16786	.45173
			1916	17 26.1W	69 37.6 N	.16756	.45119
Meanook....	54 37 N	113 20W	1918	27 44.3 E	77 54.5 N[3]	.12938[3]	.60394
			1919	27 41.1 E	77 54.2 N[3]	.12944[3]	.60401
Stonyhurst...	53 51 N	2 28W	1918	16 08.3W[4]	68 43.3 N	.17330[4]	.44501
			1919	15 58.6W[5]	68 43.1 N	.17306[5]	.44376
Potsdam.....	52 23 N	13 04 E	1918[6]	7 49.3W	66 30.8 N	.18646	.42912
			1919[6]	7 39.7W	66 32.3 N	.18625	.42913
Seddin.......	52 17 N	13 01 E	1919[7]	7 41.0W	66 29.3 N	.18663	.42898
Irkutsk......	52 16 N	104 16 E	1908	1 54.0 E	70 31.6 N	.19901	.56281
			1909	1 51.3 E	70 33.5 N	.19860	.56265
De Bilt......	52 06 N	5 11 E	1915	12 12.5W	66 48.0 N	.18481	.43117
			1916	12 02.7W	66 48.8 N	.18461	.43101
			1917	11 53.6W	66 50.1 N	.18443	.43103
Valencia[8]....	51 56 N	10 15W	1915	20 03.8W	68 07.9 N[9]	.17869	.44519[9]
			1916	19 53.1W	68 06.6 N	.17869	.44473
Kew........	51 28 N	0 19W	1916	15 08.8W	66 57.5 N	.18457	.43395

[1]See tables for previous years in *Terr. Mag.*, vol. 4, p. 135; vol. 5, p. 128; vol. 8, p. 7; vol. 12, p. 175; vol. 16, p. 209; vol. 20, p. 131; vol. 22, p. 169; and vol. 23, p. 191.

[2]Values are means for first 4 and last 4 months only.

[3]From absolute observations uncorrected for diurnal variation and made twice monthly for H and weekly for I; 1919 values are for February to December only.

[4]From magnetograph for 10 least-disturbed days in each month.

[5]From mean of 4 daily readings of magnetograms for 5 least-disturbed days in each month; I and Z from absolute observations.

[6]Provisional values.

[7]Provisional values.

[8]Two absolute observations per month.

[9]Eleven months only.

Observatory	Latitude	Longitude	Year	Declination (*D*)	Inclination (*I*)	Intensity Hor. (*H*)	Intensity Ver. (*Z*)
	° ′	° ′		° ′	° ′	*c. g. s.*	*c. g. s.*
Greenwich...	51 28 N	0 00	1918	14 27.2W	66 54.2 N	.18462	.43290
Uccle........	50 48 N	4 21 E	1912	13 05.9W	66 00.5 N[10]	.19027	.42752
			1913	12 56.8W	66 00.3 N[10]	.19021	.42732
Val Joyeux...	48 49 N	2 01 E	1915	13 40.5W	64 38.1 N	.19715	.41587
			1916	13 30.7W	64 40.3 N	.19700	.41622
Pola.........	44 52 N	13 51 E	1916	7 28.3W	60 05.6 N	.22144	.38499
			1918	7 11.0W	60 09.0 N	.22113	.38533
Agincourt (Toronto)..	43 47 N	79 16W	1918	6 38.3W	74 44.8 N	.15916	.58366
			1919	6 41.0W	74 44.9 N	.15885	.58270
Ebro (Tortosa)......	40 49 N	0 31 E	1915	12 46.0W	57 47.1 N	.23277	.36941
			1916	12 34.7W	57 46.2 N	.23306	.36967
			1917	12 24.9W	57 44.3 N	.23301	.36914
			1918	12 16.1W	57 42.8 N	.23298	.36872
			1919	12 07.6W	57 41.1 N	.23291	.36821
Coimbra.....	40 12 N	8 25W	1917	15 42.6W	58 29.6 N	.23059	.37618
			1918	15 35.6W	58 26.7 N	.23062	.37545
Cheltenham..	38 44 N	76 50W	1917	6 12.4W	70 53.6 N	.19211	.55458
San Fernando	36 28 N	6 12W	1914	14 44.0W	54 23.7 N[11]	.24977	.34881
			1915	14 36.0W	54 19.1 N[11]	.24978	.34784
			1916	14 28.5W	54 15.8 N[11]	.24958	.34686
			1917	14 21.1W	54 09.0 N[11]	.24986	.34580
			1918	14 12.4W	54 02.2 N[11]	.24976	.34423
Tucson......	32 15 N	110 50W	1918	13 47.2 E	59 27.1 N	.26973	.45703
Lukiapang...	31 19 N	121 02 E	1913	3 07.2W	45 32.6 N	.33233	.33870
Dehra Dun...	30 19 N	78 03 E	1916	2 11.0 E	44 37.9 N	.33050	.32627
			1917	2 06.5 E	44 44.1 N	.33010	.32704
			1918	2 01.4 E	44 49.6 N	.32980	.32782
Hongkong....	22 18 N	114 10 E	1918	0 18.0W	30 48.3 N	.37164	.22159
			1919	0 19.8W	30 47.5 N	.37171	.22151
Honolulu....	21 19 N	158 04W	1918	9 48.6 E	39 26.7 N	.28905	.23781
			1919	9 50.7 E	39 26.6 N	.28860	.23742
Toungoo.....	18 56 N	96 27 E	1916	0 08.4W	23 08.5 N	.39018	.16676
			1917	0 12.7W	23 08.5 N	.39037	.16684
			1918	0 16.5W	23 08.4 N	.39067	.16696

[10] Mean of 2 to 4 absolute values each month.
[11] Absolute values only.

Observatory	Latitude	Longitude	Year	Declination (D)	Inclination (I)	Intensity	
						Hor. (H)	Ver. (Z)
	° ′	° ′		° ′	° ′	c. g. s.	c. g. s.
Alibag.......	18 38 N	72 52 E	1917	0 32.5 E	24 35.8 N	.36875	.16880
			1918	0 28.4 E	24 43.0 N	.36886	.16979
			1919	0 24.5 E	24 49.3 N	.36899	.17067
Vieques......	18 09 N	65 26 W	1918	3 34.1 W	51 12.1 N	.27967	.34785
Antipolo[12]....	14 36 N	121 10 E	1911[13]	0 41.3 E	16 18.6 N	.38072	.11140
			1912	0 40.0 E	16 15.1 N	.38101	.11107
			1913	0 39.4 E	16 14.7 N	.38090	.11098
Kodaikanal...	10 14 N	77 28 E	1916	1 27.9 W	4 22.4 N	.37633	.02878
			1917	1 33.8 W	4 27.1 N	.37661	.02931
			1918	1 39.2 W	4 30.3 N	.37694	.02969
Batavia-Buitenzorg.	6 11 S	106 49 E	1913	0 46.4 E	31 24.4 S	.36690	.22401
			1914	0 46.2 E	31 28.8 S	.36686	.22464
			1915	0 46.1 E	31 33.6 S	.36676	.22528
Samoa (Apia)	13 48 S	171 46 W	1917[14]	10 02.9 E	29 57.8 S[15]	.35339	.20373
			1918[14]	10 05.9 E	29 59.5 S[15]	.35313	.20381
			1919[14]	10 08.7 E	30 01.5 S[15]	.35289	.20395
Mauritius....	20 06 S	57 33 E	1917	9 54.5 W	52 48.6 S	.23181	.30551
			1918	10 03.2 W	52 44.9 S	.23149	.30447
Pilar[16].......	31 40 S	63 53 W	1916	8 22.9 E	25 40.9 S	.25495	.12260
			1917	8 13.7 E	25 41.0 S	.25450	.12240
Melbourne...	37 50 S	144 58 E	1918[17]	8 02.6 E	67 51.7 S	.22940	.56386
			1919[17]	8 01.0 E	67 53.8 S	.22895	.56374
Christchurch.	43 32 S	172 37 E	1915	16 47.0 E	....	.22387	....
			1916	16 49.8 E	....	.22355	....
			1917	16 53.0 E	68 04.8 S	.22328	.55486
			1918	16 55.7 E	68 06.7 S	.22304	.55516
			1919	16 58.6 E	68 07.8 S	.22280	.55507

[12] All values referred to C. I. W. standard.
[13] Corrected values.
[14] Preliminary values.
[15] Computed from values of H and Z.
[16] To refer published values for previous years to the new wooden absolute house and to finally adopted values of distribution coefficients, corrections on published values of H, together with corresponding changes in Z and I, must be applied as follows:

1905	+.00019 c.g.s.	1910	+.00023 c.g.s.
1906	+.00018 c.g.s.	1911	+.00015 c.g.s.
1907	+.00020 c.g.s.	1912	+.00006 c.g.s.
1908	+.00022 c.g.s.	1913	+.00005 c.g.s.
1909	+.00015 c.g.s.	1914	+.00002 c.g.s.

[17] Absolute observations only.

NOTES

30. Magnetic Effects, Solar Eclipse, May 29, 1919. The discussion and analysis of the magnetic observations made in connection with the solar eclipse of May 29, 1919, have proved of such interest that it has been decided to call for additional data from various observatories.

31. Personalia. Sir *Frank W. Dyson* was elected an honorary member of the American Astronomical Society. Sir *Napier Shaw*, on September 6, 1920, retired from the post of director of the British Meteorological Office, which he has so ably filled for many years. He will perform the duties of professor of meteorology at the Imperial College of Science and Technology at South Kensington in connection with the School of Aviation recently established there in association with the University of London. He will continue to act as president of the International Meteorological Committee until a successor is appointed. *Dr. G. C. Simpson*, formerly meteorologist to the Government of India, succeeds Sir Napier Shaw as director of the British Meteorological Office, now under the Air Ministry. Captain *Edward Kidson* has been appointed supervising meteorologist for the province of Victoria, Australia, resigning his post as observer-in-charge of the Watheroo Magnetic Observatory to take effect February 1, 1921; he is succeeded by *W. C. Parkinson*.

32. Magnetic Storm on September 28-29, 1920. This storm began at the Cheltenham Magnetic Observatory at 13^h (G. M. T.), September 28 and continued until September 29, 10^h. The ranges were 44.′4 (decl'n)., 188γ (hor. int.); 341γ (vert. int.). No notable storm occurred during the period October to December, 1920.

LETTERS TO EDITOR

THE MAGNETIC CHARACTER OF THE YEAR 1919.

The annual review of the "Caractère magnétique de chaque jour" for 1919 has been drawn up in the same manner as the preceding years. Forty observatories contributed to the quarterly reviews, 37 of them having sent complete data. Table II of the annual review, containing the mean character of each day and each month, the list of "calm days" and the days recommended for reproduction, are reprinted on page 183.

G. van Dijk.

Table Showing the Magnetic Character for the Year 1919.

Dates	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Mean
January	0.2	0.1	1.4	1.9	1.6	1.2	0.9	0.8	0.5	0.1	0.1	0.4	1.2	1.2	0.7	1.4	1.3	1.4	1.2	0.9	0.7	0.8	0.5	0.2	0.0	0.0	0.0	0.7	0.8	0.5	1.6	0.78
February	1.4	1.2	1.1	0.9	1.0	0.7	0.1	0.2	0.5	0.0	0.0	0.2	1.3	1.4	1.0	1.1	0.5	0.7	0.2	0.7	1.6	1.4	1.4	0.5	0.0	0.2	1.2	1.9				0.81
March	1.4	1.5	1.1	1.0	0.8	1.0	0.8	0.3	0.1	0.0	0.4	0.9	0.7	1.2	0.5	0.9	0.9	0.0	1.3	1.7	1.7	1.7	1.1	0.0	0.7	0.4	1.2	1.4	1.0	1.0	1.0	0.89
April	0.6	0.1	0.1	0.9	0.0	1.1	1.4	1.2	0.7	0.7	0.4	0.7	0.4	0.0	0.4	1.4	1.8	1.4	1.0	1.0	0.9	0.9	0.9	0.8	0.3	0.0	0.4	0.2	0.8	0.6		0.70
May	0.4	1.9	1.8	0.8	1.0	0.7	0.3	0.1	0.5	0.5	0.0	0.6	1.6	1.2	0.9	0.6	1.1	0.9	0.6	0.8	1.5	1.3	0.6	1.5	1.0	1.2	0.9	0.1	0.1	0.2	0.2	0.82
June	0.5	0.5	0.4	0.4	0.5	0.5	0.1	0.1	1.1	1.3	1.1	1.0	0.6	0.2	0.3	0.1	0.6	0.4	0.1	0.1	0.2	0.6	1.1	0.9	1.0	1.0	0.4	0.7	0.7	0.1		0.55
July	0.9	0.5	0.8	0.3	0.1	0.0	0.5	1.1	0.9	0.6	0.6	0.4	0.6	0.5	0.0	0.1	1.4	1.1	0.4	0.2	0.2	1.1	1.6	1.1	0.3	0.2	0.2	0.1	0.4	0.3	0.4	0.54
August	0.8	0.8	0.6	0.6	0.8	0.2	0.5	0.7	0.3	0.4	2.0	2.0	0.1	0.2	0.6	0.5	0.6	0.9	1.6	1.0	0.4	0.3	0.7	0.5	0.6	1.0	0.5	1.1	0.8	0.6	0.2	0.70
September	0.0	1.5	1.1	1.0	0.2	1.4	1.1	0.4	1.1	0.7	0.7	0.1	0.9	0.9	0.9	0.9	0.8	1.0	1.8	1.5	1.0	0.7	0.9	1.6	1.1	0.7	0.3	0.1	0.2	0.1		0.83
October	1.8	1.4	1.7	1.5	2.0	1.5	0.9	0.8	1.1	0.5	0.7	0.2	0.1	0.0	0.9	1.2	1.1	1.0	0.4	0.5	0.2	1.3	1.3	0.3	0.0	1.1	1.2	1.3	0.9	0.6	0.7	0.91
November	0.1	0.3	0.2	1.5	0.5	0.2	0.1	0.2	0.1	0.1	1.2	1.1	0.4	0.1	0.3	1.4	1.2	1.0	0.1	0.1	0.7	1.3	0.7	0.6	0.5	0.5	0.1	0.1	0.3	0.6		0.52
December	0.2	0.2	1.0	0.9	0.9	0.6	0.4	0.7	0.5	0.6	0.5	0.7	1.0	1.5	2.0	0.9	0.1	0.5	0.8	0.9	1.0	1.1	0.9	1.1	0.6	0.0	0.2	0.1	0.1	0.2	0.1	0.66

Calm Days

January	2,	11,	25,	26,	27	February	7,	10,	11,	12,	25	March	8,	9,	10,	18,	24
April	3,	5,	14,	26,	28	May	7,	8,	11,	28,	29	June	7,	8,	19,	20,	30
July	5,	6,	15,	16,	28	August	6,	9,	13,	14,	31	September	1,	5,	12,	28,	30
October	12,	13,	14,	21,	25	November	7,	9,	14,	19,	20	December	1,	17,	26,	29,	31

Days Recommended for Reproduction.

**August 11; September 19; October 5.

*January 4, 5; February 28; March 20; May 2; September 2, 24; October 1, 4; December 15.

CONCERNING THE TOOLANGI MAGNETIC OBSERVATORY, AUSTRALIA, AND MAGNETOGRAM SCALINGS.

There seems so little to say about the Toolangi Observatory that differs from the United States Coast and Geodetic Survey observatories that no detailed description of the buildings is at present worth while. The *D*- and *H*- records are quite satisfactory, but the *Z*- instrument is still liable to disturbance from accidental jars and the adjustment of scale value to any desired sensitiveness is difficult. The site is a curious contrast to the site of the Watheroo Magnetic Observatory; the neighborhood is heavily timbered, and at present the big logs that had to be felled when clearing the site lie around.

Unfortunately no staff is available here for the measurement of the magnetic curves, and no money has been provided for printing. I am keeping on the records in the hope that it may be possible to obtain additional assistance for carrying out the work.

I had given consideration to the question of procedure, and for some years now all times used for the magnetic work here have been Standard time 10^h E (long. of Melbourne is $9^h\ 40^m$ E). The following general procedure appears to me to be best:

a. In the publication of the magnetic data in full the standard time corresponding most nearly to local mean time be adopted.

b. Selected days should refer to simultaneous intervals, and be from Greenwich midnight to Greenwich midnight.

c. For special phenomena, the time should always be expressed in Greenwich Mean Time.

d. The hourly readings should be the mean ordinate for the hourly interval.

e. The hourly interval should center at the half hour.

I had arrived at these conclusions before I saw the other opinions in the December 1919 number of *Terrestrial Magnetism*, so that they are independent although much the same as opinions expressed there.

When it is possible for me to publish, I am willing to make the publication conform as closely as possible to recommendations made by the Section of Terrestrial Magnetism and Electricity of the International Geodetic and Geophysical Union.

J. M. BALDWIN, *Director*.

South Yarra, Melbourne,
August 2, 1920.

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Angenheister, G. Ueber die Fortpflanzungsgeschwindigkeit erdmagnetischer Störungen und Pulsationen. S.-A. Göttingen, Nachr. Ges. Wiss., 1920, 7 pp. [*Cf. Terr. Mag.* vol. 25, 1920, pp. 26-32.]

Angenheister, G. Sonnentätigkeit, Sonnenstrahlung, Lufttemperatur und erdmagnetische Aktivität im Verlauf einer Sonnenrotation. Vorläufige Mitteilung. S.-A. Göttingen, Nachr. Ges. Wiss., 1920, 8 pp. [This article is also published in the March 1920 issue of this Journal, pp. 17-26.]

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